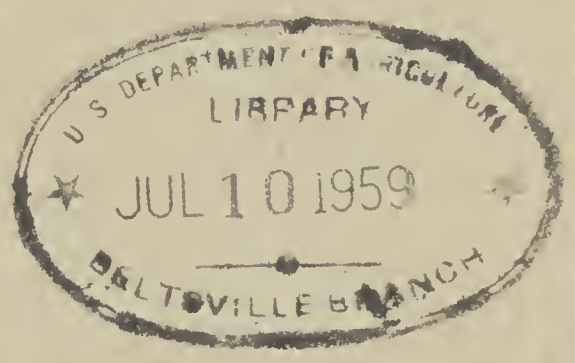
GUAM AGRICULTURAL EXPERIMENT STATION,
C. W. EDWARDS, Animal Husbandman in Charge.

Under the supervision of the STATES RELATIONS SERVICE,
Office of Experiment Stations, U. S. Department of Agriculture.

REPORT OF THE GUAM AGRICULTURAL EXPERIMENT STATION.

1920.

Issued November 21, 1921.



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GUAM AGRICULTURAL EXPERIMENT STATION, ISLAND OF GUAM.

[Under the supervision of A. C. TRUE, Director, States Relations Service, United States Department of Agriculture.]

E. W. ALLEN, *Chief, Office of Experiment Stations.*
WALTER H. EVANS, *Chief, Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF.

C. W. EDWARDS, *Animal Husbandman in Charge.*
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PETER NELSON, *Assistant.*

LETTER OF TRANSMITTAL.

GUAM AGRICULTURAL EXPERIMENT STATION,
Island of Guam, February 26, 1921.

SIR: I have the honor to transmit herewith a report of the Guam Agricultural Experiment Station, 1920.

Very respectfully,

C. W. EDWARDS,
Animal Husbandman in Charge.

Dr. A. C. TRUE,
Director, States Relations Service,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
HENRY C. WALLACE, *Secretary of Agriculture.*

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By C. W. Edwards.

SUMMARY OF WORK OF THE YEAR.

Definite progress was made in all branches of the station's activities during the fiscal year ended June 30, 1920, and the results on the whole were satisfactory, although the scope of certain projects was necessarily curtailed by the high cost of materials and labor and a limited appropriation.

In the animal-husbandry division, the main projects comprise (1) the work of establishing improved station breeding herds and flocks, (2) the upgrading of privately owned stock, and (3) the conducting of feeding and management tests. In the feeding tests special experiments were carried on to determine which of the local feeds were most suitable for horses and cattle. Under the horse-breeding project cooperative arrangements were made with various ranchers to lease and fence a pasture area adjoining the station, so that privately owned mares could be brought in and kept until it was reasonably sure that they were in foal by the station purebred Morgan stallion. In connection with the poultry project work was continued on breeding pure Rhode Island Reds and in developing an improved native strain as foundation stock for the establishment of a new locally adapted variety. Individual pedigrees are being kept in connection with all the breeding work.

The live-stock industry of the island was greatly facilitated by the importation, in February, 1920, of purebred pigs and chickens from the United States. This shipment consisted of 81 chickens, 16 pigs, and 2 bulls. Two boars, 2 bulls, and 10 chickens were purchased by the station for its breeding work. The others, which were purchased from funds supplied by the island government, were sold to residents of the island at cost under the supervision of the station. These animals were personally selected in the United States by Glen Briggs, agronomist and horticulturist of the station, who also super-

vised their shipment to Guam on a Navy transport. So far as is known, this is the first importation of purebred breeding stock for sale to the public since the American occupation of the island. A large number of the pigs and chickens were placed on exhibit at the 1920 Guam Industrial Fair, where they attracted much attention. It is planned to import small shipments of this kind of stock from time to time for sale to island ranchers to improve their live stock.

The principal agronomic investigations conducted during the year were those dealing with forage crops, corn, rice, root crops, and soils. Special attention was given to work with forage crops, particularly to those which can be used as cover and green manure crops. In the corn investigation the ear-to-row breeding work was carried to the eleventh generation. The soil studies were continued on a more extensive basis than formerly. Tests with tobacco and cotton were continued.

In the horticultural division, attention was focused on cultural methods, the improvement of tropical fruits and vegetables, and the adaptation to Guam of varieties imported from other countries. Experimental work with garden vegetables was completed after 10 years, and the data obtained are being prepared for publication. The distribution of seeds and economic plants was also an important work of this department.

Work in the extension division was continued along the lines outlined in last year's report. There were three general projects: Adult demonstrations, school gardens, and boys' and girls' club work. The adult work was conducted largely in connection with the Guam Industrial Fair and the district fairs. In cooperation with the local department of education, gardens for the instruction of pupils and for demonstration purposes were maintained at each of the schools of the island. The boys' and girls' club work has been found to be the most popular line of extension work. Two seasons' work with this project was completed and some definite results are already beginning to be noted.

ANIMAL HUSBANDRY.

HORSES.

The work with horses was confined chiefly to efforts directed to upgrade the inferior native ponies by crossing them with the purebred Morgan stallion. Former efforts in this line were hampered by the ranging of most of the native mares in isolated districts. In these districts they were given little or no attention, and it was impossible to get the owners to bring them in at the proper time for service or to return them afterward to the distant ranches. It was,

therefore, deemed important to provide means whereby a number of these mares at a time could be brought in and kept at the station until they were in foal. Through the cooperation of the horse owners, pasture areas adjoining the Piti station property were leased and fenced during the early part of the year. From 13 to 15 of the native mares were kept here during the year, the greater number of which were bred before the close of the period.

A number of the mares were apparently barren, and in many cases several services were required to get others in foal. At the close of the year a few still seemed to be nonpregnant. Judging from the results with the few American mares bred during the season, the fault in the main is not due to impotency in the sires. In the majority of cases it was difficult to determine the period of heat of the native mares. This, to some extent, was probably due to the fact that the mares were wild and more or less afraid of the large stallion. They do not, however, show as marked œstrum symptoms as do American mares, and in no instance have they shown the œstrum during gestation as is often the case with American mares in the Tropics. Owing to the difficulties experienced in getting the mares in foal, the plan of allowing the stallion to run with the herd was tried. A proper service was not accomplished, however, on account of the difference of the size of the sire and the mares, and the practice was discontinued.

Some data were secured on the comparative efficiency of Paspalum and *Andropogon aciculatus* (inifuk) grasses in the maintenance of native ponies on pasture alone. From January 1 to the close of the fiscal year three native brood mares were maintained in good condition on an area of two acres of well-established Paspalum. During the same period a pasture of approximately 14 acres of native grass was insufficient to maintain 10 native brood mares in the same relative condition. This was true especially during the months of January and February, which was a period of comparative drought. These two pasture lots are on the lowlands and are very similar in soil type. This and other observations indicate that, except during periods of long drought, well-established lowland Paspalum pastures will easily support two head of native ponies per acre.

CATTLE.

The importation from the United States of two young purebred Ayrshire bulls meets a need that has been urgent since the death in 1917 of the Ayrshire sire Harry Gray. These bulls, which were obtained in California, are good type individuals and have shown normal growth and development since their introduction. One

of the bulls, Steybræ Master Douglas (Pl. I, fig. 1), was sired by Willowmoor Robin Hood 32d out of Willowmoor Jean Douglas, and the other, Steybræ Lord Sterling, was sired by Willowmoor Robin Hood 32d out of Eva of Chateaugay.

Some of the cattle of the breeding herds, especially in the Piti district, were in thin flesh at the beginning of the year as a result of the long drought of the previous year. With the improvement of pastures following the July rains, their condition improved rapidly. For the remainder of the year, with the exception of short periods during the months of January and February, there was an abundance of green forage, and the herds kept in good condition throughout the period. No loss from disease was sustained, although a number of the cattle died from accident or other cause.

Purebred sires were used at Piti to upgrade the station herds and produce improved stock for distribution. At Cotot, although as many as possible of the grade heifers were brought to Piti for service, the use of a grade sire was continued, because this station is not equipped with facilities to care properly for purebred sires. Moreover, the aged Ayrshire bull, John Gray, was not in condition to be transferred, and it was desired to keep the two recently imported young bulls under close observation at Piti during the period of acclimatization. It is hoped that funds will soon be available for the provision of housing and other facilities at Cotot, so that the purebreds can be properly maintained at that station.

During the year seven young grade bulls and six male grade calves were disposed of to the public for use as breeders. A few of the station grade bulls were lent to ranchers. No doubt all the cattle of the island could be improved were the station to retain ownership and full control of the surplus bulls and lend them out for use in various districts. A number of near-by cattle owners availed themselves of the free services of the purebred bulls at the Piti station.

The increase in station cattle by birth during the year numbered one purebred Ayrshire and 11 grade Ayrshires. Through exchange for station breeding stock, 12 native heifers were added to the Cotot herd.

Other important phases of the work being conducted under this project include feeding tests, tick investigations, studies of the coat character regarding length and density, introduced purebreds and their grades, the collection of data on the comparative milk yield of purebred, grade, and native cows, and efforts to determine, if possible, the causes responsible for any decrease in milk yield and in size of introduced and locally raised purebreds. In addition to the investigations made at this station, information is being ob-

FIG. 1.—PUREBRED AYRSHIRE BULL, STEYBRAE MASTER DOUGLAS.

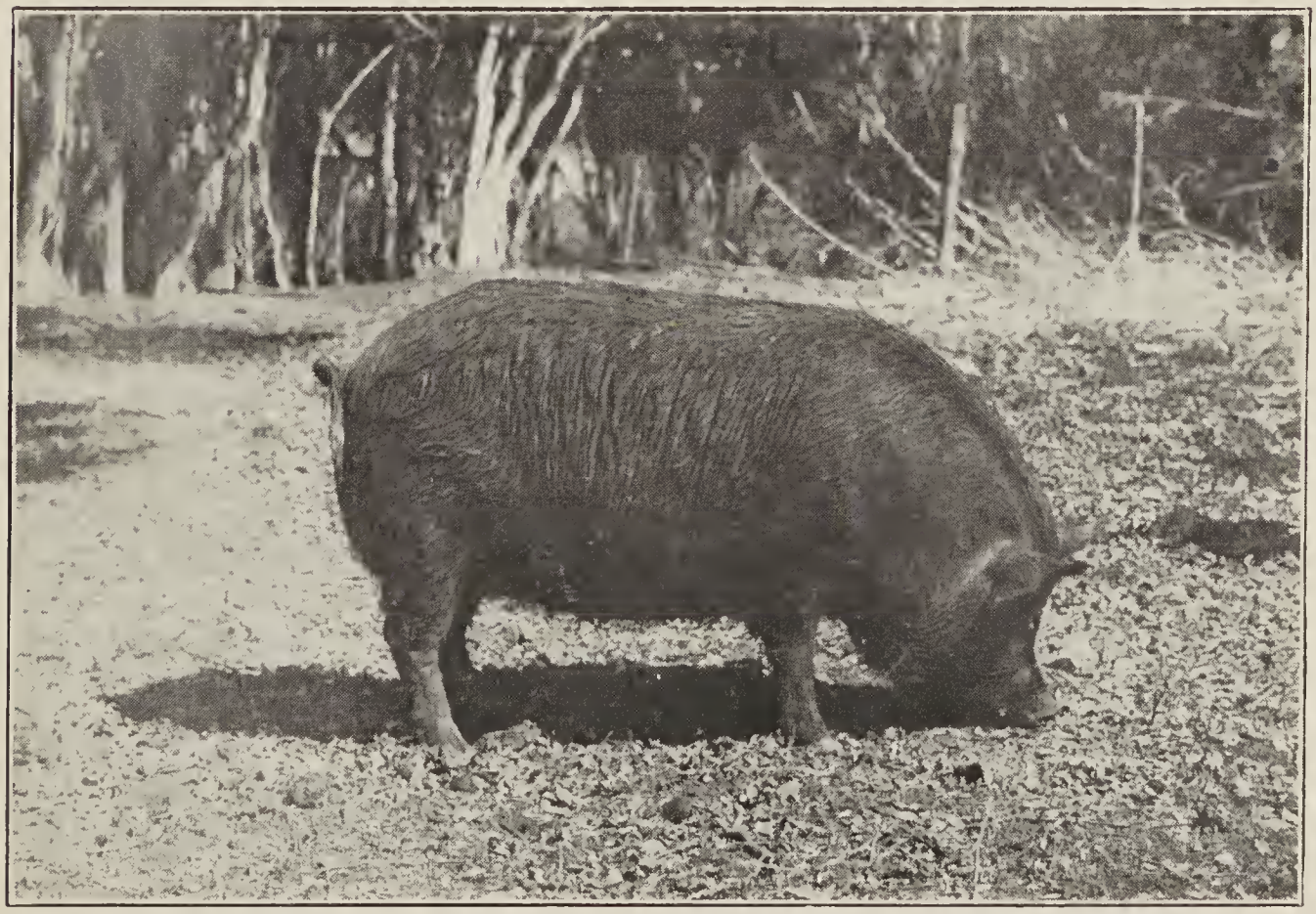

FIG. 2.—STATION-BRED GRADE BERKSHIRE GILT. SEVEN-EIGHTHS BERKSHIRE, ONE-EIGHTH NATIVE.

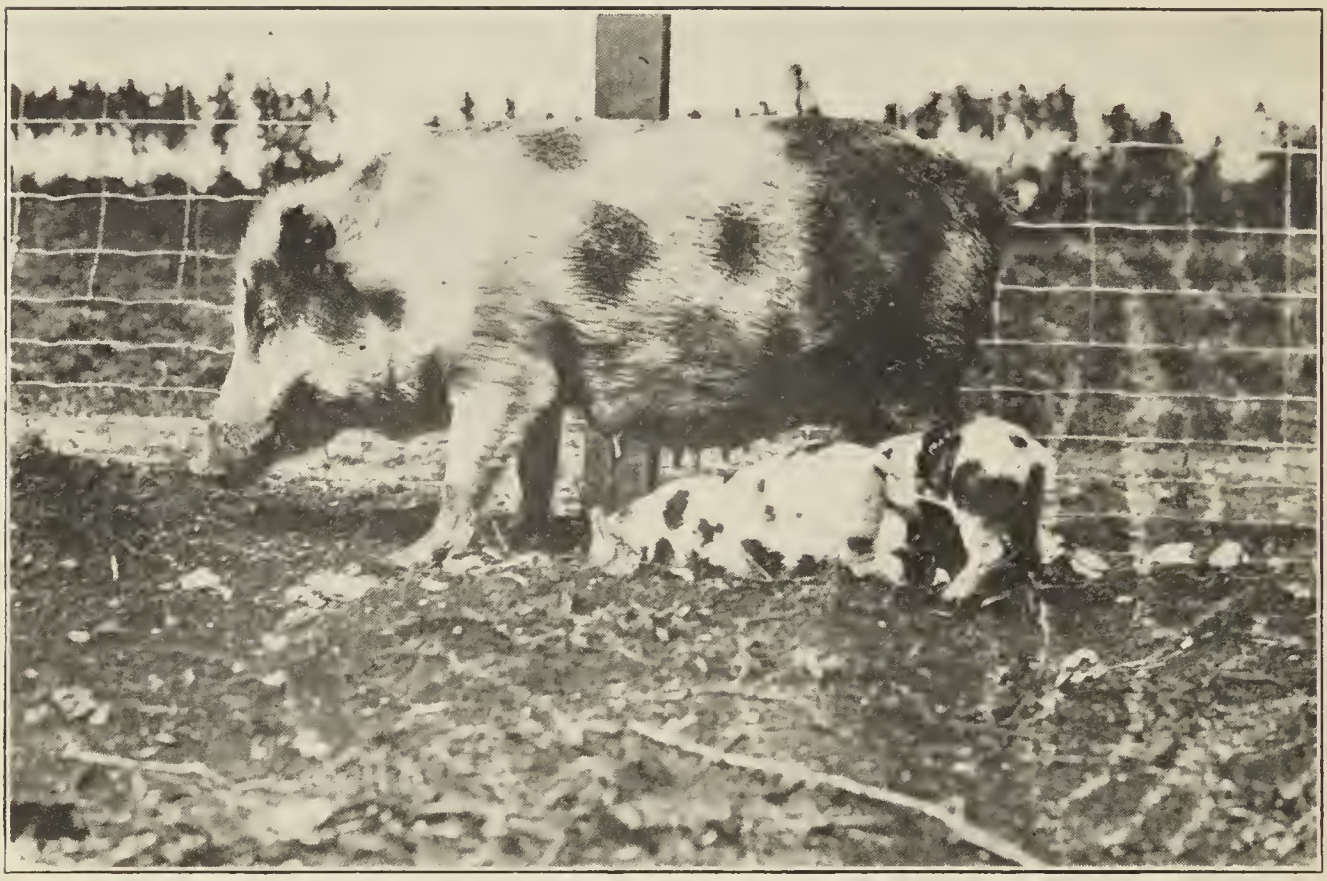

FIG. 1.—NATIVE SOW, NO. 1. ESTIMATED WEIGHT 150 POUNDS.

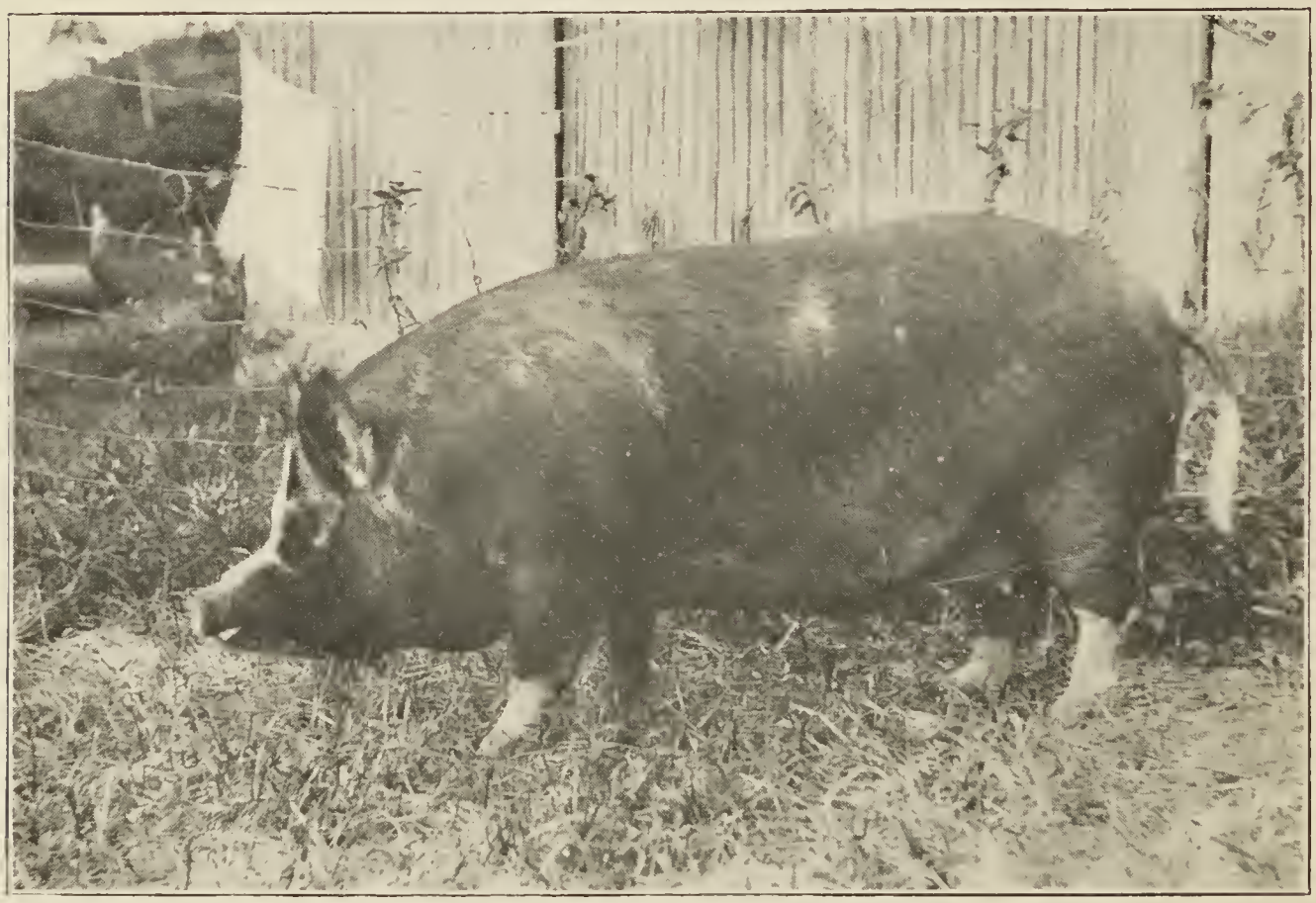

FIG. 2.—GRADE BERKSHIRE SOW, GRANDDAUGHTER OF ABOVE. WEIGHT, 550 POUNDS.

tained on these subjects from other tropical stations where work with cattle is being carried on. The present small number of purebred and grade animals on hand, and the limited equipment and labor necessitate the carrying of these tests over a long period.

The following table shows the total number of cattle on hand at the close of the year:

Cattle on hand at the close of the fiscal year 1920.[1]

Breed.	Number of cows.	Number of bulls.	Young stock.		Calves.		Total.
			Males.	Females.	Males.	Females.	
Ayrshires	3	1	2	1	.....	1	8
Grade Ayrshires	10	4	1	8	5	5	33
Grade Jersey	1	.....	.....	.....	.....	.....	1
Natives	14	.....	.....	4	2	.....	20
Total	28	5	3	13	7	6	62

[1] Males 3 years old or over are raised to bull class; heifers 3 years old or over are raised to cow class; calves 1 year old or over are raised to "young stock" classification.

SWINE.

The work of establishing a purebred herd of swine through upgrading has been retarded for some time by the inability of the station to acquire purebred sires. In the meantime, grade boars were used in the production of stock for experimental work and distribution for breeding purposes, as well as for use in conducting feeding and other tests (Pl. I, fig. 2).

The need of sires for the station was met in February, 1920, by the importation of two young Berkshire boars, Notamas Star 281794, sired by Hedgemere Star out of Livermore Rosemeade, and Notamas Master Lee 2d 281787, sired by Ideal Royal Lee out of Mistress Noreon. These boars have made good growth since their importation. One of them, however, has so far shown a disinclination to breed, a tendency which has been noted to occur occasionally among boars imported into the Tropics. In the cases observed by the writer here and in the Philippines, most of the animals became normal after a period of acclimatization. Eleven of the 14 young Berkshire boars imported for sale to the farmers of Guam were exhibited and sold during the Guam Industrial Fair in February; the other three were disposed of later.

Near the close of the fiscal year the entire island government herd, consisting of some 80 grade Berkshires, the foundation stock of which had been obtained from this station, was disposed of. Many of these animals were sold as breeding stock to farmers and to members of the boys' and girls' clubs. As a result of the importation in February, and the distribution of the island government stock and the station

stock in other years, there should soon be apparent a general improvement in the swine of the island, particularly in the northern and central districts (Pl. II, figs. 1 and 2). Very few of the improved animals have as yet been obtained by farmers in the southern part of the island. The station hopes to place some stock in this locality in the near future.

Some cases of barrenness or shy breeding occurred in the station herd during the year. These are the first instances of this nature recorded among the locally-raised grade Berkshires. Late breeding is thought to have been the cause of this barrenness, as the sows, which were held until the arrival of purebred sires, were not served until some time after they had reached maturity.

During the year two deaths from kidney-worm infection occurred among the station animals.

FEEDING EXPERIMENTS.

Cowpeas.—It is difficult to induce the Chamorro farmer to grow crops for utilization as stock feeds only. His primary object in growing any crop is to produce food for human consumption, and his live stock receive only the waste portions. For this reason the station has been much more successful in getting the people to grow cowpeas than in getting them to grow the other legumes. Owing to their comparatively low grain yield, cowpeas are not as profitable a swine feed as are some of the other legumes. However, as cowpeas are the only protein field crop available on many ranches (with the exception of mungo beans), it is thought that, under the circumstances, small quantities might well be fed at times to growing pigs. The swine rations generally fed by the local rancher are extremely bulky and of very low protein content. It is not unusual for the feed, even for growing animals, to consist entirely of root crops and green roughage. Fresh coconut is commonly fed, though at certain seasons it is given sparingly or not at all. It would be well, therefore, for the farmers to know the value, especially for growing pigs, of using corn, root, and other carbonaceous feeds with cowpeas.

Corn versus corn and cowpeas.—A test of 60 days' duration was conducted to compare the value of an entire corn ration with one consisting of a mixture of corn and cowpeas as a feed for growing swine. One lot received a mixture composed of one-third coarsely ground cowpeas and two-thirds cracked corn, by weight, while a second lot received cracked corn only. Both lots were pastured on new growth Paspalum and received the same quantity of grain daily. In this test the two groups showed practically no difference in total gain. One-half acre of Paspalum furnished sufficient pas-

turage for the 12 pigs throughout the test. Frequent rains occurred during the period, and the stand of grass was in no way injured by the pasturing.

Later, five grade pigs running on Paspalum were fed for a period of 50 days on a ration consisting of equal parts by weight of cracked corn and cowpeas. These pigs were younger than the pigs in the above-mentioned experiment and made an average gain considerably above that of either lot of grades in the previous test. Where the pigs are kept on a small dry lot, as is often the practice on local ranches, results doubtless would be in favor of the mixed ration.

Rotation crops for swine.—In connection with swine raising on the island it is important that studies be made to determine the most suitable rotations for the production of crops during different seasons, or throughout the year. During part of the year initial work of this nature was conducted in the feeding of gilts and brood sows. Only a limited number of animals were available for use in these tests.

During October and November sweet potatoes (pastured) supplemented with velvet beans in the pod and tankage gave good results as feed for grade gilts, as did Para grass pasture supplemented with corn and tankage during December and January. During March and April velvet beans (the crop was beginning to mature at the time it was hogged-off) supplemented with corn, and during May ripe kafir (hogged-off) supplemented with tankage, were found to be satisfactory rations for grade brood sows. During June cooked breadfruit fed in combination with velvet beans in the pod gave satisfactory results with grade brood sows.

Dried Lima beans as a feed for growing swine.—A 60-day test was carried on with 10 young native pigs, one group receiving cracked corn, and the other group a mixture of equal parts, by weight, of dried Lima beans (cooked) and cracked corn. Both groups of pigs were pastured on Paspalum. In this test the cracked corn and the mixture of corn and beans were practically equal in feeding value. In later tests the beans gave about the same results that corn gave with pigs pasturing on new growth Paspalum. The beans were a lot which had been condemned because they were infested with weevils. Only under unusual circumstances should Lima beans be fed to swine. However, as was true in this case, there might be instances where data relative to their feeding value would be useful.

PORTABLE COLONY PENS.

Two portable colony pens, 10 by 20 feet, constructed of 1 by 6 inch material, were used during the year with very satisfactory results. A small house of cheap construction was provided for each

pen, which will accommodate one sow and litter, a number of weanlings, or three or four growing swine. A pen of this sort could be constructed of bamboo, and will be found especially valuable to the rancher who has little or no fencing. If the pens are moved frequently the pigs can more easily be kept free of intestinal parasites than they can when permanent lots are used.

GOATS.

Upgrading the station herd of native and grade goats by the use of Toggenburg blood was retarded for some time through inability to obtain pure-blood sires. Improvement through general selection has continued, but it has been necessary during this time to use grade sires. The suitable surplus stock is sold to the public for breeding use.

It was hoped to purchase at least one pure-blood Toggenburg sire when the other breeding animals were obtained for the station in February, but good Toggenburg stock was scarce, and the few animals which were offered for sale were held at such exorbitant prices that their purchase by the station was deemed impracticable.

During the year two grade bucks were loaned out, and one grade female and five young grade bucks were sold to the public for breeding purposes. The total increase by birth in the station herd numbered 15 grades. A number of deaths occurred from various causes, though comparatively few actually resulted from disease. The rotation of pastures, the copper-sulphate treatment, and a medicinal salt (made up of lime, sulphur, salt, and copper sulphate) which were kept before the herd apparently were instrumental in reducing the loss from internal parasites.

The collecting of data on the milk production of grade and native goats was continued.

CHICKENS.

The chicken industry in Guam is conducted on a comparatively small scale and under very poor management. The work is steadily growing, however, with the increasing demand for fresh eggs and meat. The demand for poultry products was in former times confined chiefly to the needs of the rancher's family, but within recent years a good market for these products has been created by the increased foreign population and the numbers of Chamorros who are engaged in employment other than farming. The recent establishment in Guam of a copra mill is another factor which should assist in building up the poultry industry, as the by-product meal from the mill will doubtless provide a valuable addition to the rather limited supply of locally grown cheap feeds.

Until recently, fighting strains of chickens, mostly of the so-called Saigon variety, were the only ones bred for a definite purpose. They were raised for the production of gamecocks, in which vigor was generally promoted at the expense of other desirable characteristics. That the farmers are turning their attention to breeding for economic production is shown by the increased demand for improved stock for egg and meat production rather than for fighting qualities. The station, with its present limited equipment, can not begin to supply the requests for locally produced purebred and high-grade fowls. The imported purebred stock of the introduction made during the year found a ready market at prices much in excess of those ever paid before for breeding chickens in Guam.

During February the station received the largest recorded shipment of purebred chickens ever brought to the island. This shipment consisted of 73 Single Comb Rhode Island Reds, 6 Single Comb White Leghorns, and 2 Single Comb Black Minorcas. Of this lot, 10 Rhode Island Red pullets were brought in for the station and the remainder for the island government for disposal to local breeders. The station exhibited and sold the Rhode Island Reds at the February fair at Agaña.

The station work with poultry during the year was interfered with by the lack of sufficient houses and equipment. The entire plant is very much in need of repair, and a modern brooder and incubator house, as well as laying and colony houses, runs, and equipment, is needed for the proper development of the industry.

BREEDING AND INCUBATION.

The breeding work was confined to the production of purebred Rhode Island Reds for station use and for distribution, and to the production of a new progeny by crossing select pure native fowls with the Rhode Island Red. Some of the native hens have made good records in egg production, which shows that the general low prolificacy of the native hen is due principally to lack of feeds and proper management. A good strain or variety of native chickens should, therefore, be developed through selection within a comparatively short time. Individual pedigrees are now kept of all the breeding stock at the station instead of pen pedigrees.

In addition to the improved surplus stock, a number of hatchings of eggs were distributed during the year. Incidental to the regular breeding work, some data have been accumulated relative to incubation and brooding.

Period of incubation.—Those who received sittings of eggs were furnished with blank forms on which to record and submit data relative to the period of incubation, the percentage of hatchability, and the like. Records were received of 89 sittings, and data were kept

on 40 hatches incubated artificially at the station. Of the total number of sittings hatched by the natural method, the period of incubation (number of days from time eggs were placed under hen until hatching ceased), according to the records submitted, varied from 17 to 23 days. Only one hatch was recorded as completed on the twenty-third day. The period of incubation for artificially hatched chickens varied from 19 to 22 days. In the latter case the incubator was run at an average temperature of 102.4° F., and the eggs hatched on the nineteenth day, while where the temperature showed an average of 103° F. the eggs were not completed until the twenty-second day, and vice versa. The results evidently indicate that within certain limits the periods of incubation of the hatch is not dependent entirely upon the degree of temperature, but that there are other more potent controlling factors.

FEEDING EXPERIMENTS.

An experiment including two feeding tests was conducted during the year with chicks ranging from 6 to 12 and from 12 to 24 weeks of age. This experiment was the completion of a test begun in 1919, when corn alone as a ration was compared with a ration consisting of equal parts corn and mungo beans. The mungo bean is valuable as a chick feed, and was used in this simple combination to demonstrate its efficiency as such to the local farmers. It grows well on most soils and should be grown not only for human consumption, but also for animal feed.

Mungo beans as part ration for chicks from 6 to 12 weeks of age.—This test was conducted for six weeks with 156 chicks under semi-confinement. One lot was fed corn alone, while the other received equal parts of corn and mungo beans. The mortality in the two lots was equal, but the lot fed corn and mungo beans made a more uniform growth and showed more health and vigor than the lot receiving corn alone, in addition to making an average gain of 2.57 ounces more per chick.

Mungo beans as part ration for chicks over 12 weeks of age.—This test, covering a period of 12 weeks, was made with 100 chicks on free range. One lot was fed equal parts corn and mungo beans, while corn alone was given the other lot. The chicks were weighed at the end of six weeks and again at the completion of the test. The average gain in weight per chick was practically the same in the two lots. However, from the standpoint of health and vigor, the results were decidedly in favor of the mixed rations.

Grated coconut as a ration for chicks over 12 weeks of age.—This test was conducted as a practical demonstration to prove to the local farmers that grated coconut, when used alone, is inefficient as a chicken feed. A total of 134 chicks was used in the test, which was

conducted on free range. One lot was fed fresh-grated coconut, while the other was fed corn. The average gain in weight per chick in favor of the corn ration was 5.38 ounces at the end of six weeks, and 9.09 ounces at the end of 12 weeks. The mortality in the coconut-fed lot was much higher than in the corn-fed lot. The surviving chicks in the lot given coconut also showed lack of vitality and developed many culls.

For chickens, coconut should be used only as a supplementary feed. Corn, kafir, sorghums, and beans are also produced locally, but only in sufficient quantities for human consumption. Grated coconut and maize are the feeds most commonly used for poultry. Maize is harvested twice a year and is generally used only during harvest time and shortly afterwards. Coconut is used during the rest of the year, though seldom as a supplementary ration. Diseases are largely traceable to improper feeding, which has been one principal reason why the poultry industry in Guam has not made progress. Feeding methods should be thoroughly studied, because a better knowledge of the proper use and conservation of local products will eventually result in a decided improvement in the poultry industry. It is hoped that more extensive experiments than those above outlined can be conducted by the station.

Trial plantings of *Paspalum dilatatum* were made in four of the chicken runs. The grass in three runs remained in good condition throughout the season and provided much of the green feed for the breeding flocks penned therein. Tests along this line will be continued.

DISEASES.

With the exception of white diarrhea, which caused a heavy loss of baby chicks, no disease of a serious nature occurred at the station. A mild case of chicken pox occurred among the station flocks, starting with the then recently imported pullets, but no deaths resulted from it.

REPORT OF THE AGRONOMIST AND HORTICULTURIST.

By Glen Briggs.

AGRONOMY.

Satisfactory progress was made during the year in nearly all of the agronomic work, notwithstanding certain adverse conditions. On account of the very high cost of materials and supplies, and to some extent of labor, many of the tests which had been begun on a field basis were reduced to a plat basis.

Special emphasis was placed on the production of important local crops, introduced crops for which there was need and demand, and practical problems connected with these crops as they applied to the island. In the study of field crops particular attention was given to forage and root crops, corn, rice, and legumes. Tests of tobacco and cotton were also carried on, and soil studies were made on a more extensive basis than formerly. A large number of ranches were visited, and advice was given as to proper cultural methods for corn and other important field crops. Inquiries were made and data obtained relative to experiments carried on with Guam corn.

The station's continued efforts to benefit the agriculture of the island by pursuing studies relating to crops and by encouraging the introduction and adoption of modern farm implements are beginning to bear fruit. Among local farmers there is a growing demand for agricultural information and a strong inclination to follow the methods and practices suggested by the station. This is not the result of a single year's work, but rather of 12 years' experiments with many kinds of economic plants and soils. It has always been the aim of the station to make the results of its efforts as valuable as possible to Guam in particular and to the science of agriculture in the Tropics in general.

Several meetings and conferences concerning agricultural matters and fairs were attended by the agronomist during the year. Two trips over the whole island were made and different districts where cooperative work was in progress were visited a number of times. The agronomist also helped to prepare the exhibits of the station for the July and February fairs, served on the fair committee, and acted as a judge of the horticultural and agricultural exhibits. From September 14, 1919, to February 4, 1920, he was absent from the station on official business. A number of the State experiment stations were visited, and five weeks were spent in California and one week in the Hawaiian Islands, where agricultural conditions were studied. During the trip live stock, plants, and supplies were secured for the station.

FORAGE CROPS.

Forage-crop investigations continued to be an important feature of the agronomy work. For generations the Guam farmer has raised live stock by a practice which does not require the production of feed from cultivated crops. Wild grasses and native plants are depended upon for feed, even in the dry season, when they make very poor growth. The station has repeatedly demonstrated that introduced forage crops can be raised advantageously in Guam, and that they are very much superior to the native plants. It has also

been shown that cattle pasturing on the introduced grasses or feeding on other forage of high feeding value are a great improvement over the animals fed on native forage. Legumes and sorghums are among the best annual forage crops, especially for the dry season, and Paspalum and Para grasses have given satisfactory results for permanent pastures and soiling crops. The Chamorro farmer, while rather slow to adopt the practice of planting better forage crops, is beginning to realize the necessity of growing the introduced grasses, and plantings are gradually being extended to various parts of the island.

GRASSES.

For several years various experiments have been carried on relative to management, renovation, care, fertilization, and treatment of Para and Paspalum grasses. Methods and time of planting, as well as distances or rates of planting, carrying capacity, feeding tests, and data relative to cost of establishing improved pastures, were secured from many tests covering long periods. A bulletin entitled "Para and Paspalum: Two Introduced Grasses of Guam," and giving much detailed information regarding these tests, was prepared for publication.

At the beginning of the year, after the rains began, the area of improved grasses was extended to provide for increasing herds of station stock. About 35 acres at Cotot was planted to Paspalum and Para grasses, a portion of the plantings being so arranged that comparative pasture tests could be carried on. At Piti about 6 acres of Paspalum was planted. At Cotot about 9 acres of woodland and 6 acres of upland were prepared for planting the coming season. The upland had formerly been planted to Para, which was killed by pasturing. The rains were so frequent the greater part of the year that clearings could be burned only during a part of January and February.

Para grass (*Panicum barbinode*).—Para grass continued to be the main soiling crop fed to the animals at the station. Several new plantings were made on the low ground during the year and furnished a large supply of forage for the animals kept in the barns. In the fertility plats previously reported upon, Para grass was heavily pastured throughout the year. The plat was not kept clean of volunteer growth and now contains a large mixture of native grasses. This shows that plats planted to Para require proper pasture management, renovation, and fertilization Para grass is perhaps more palatable to all classes of live stock than is any other grass grown on the station grounds. Nearly all classes of live stock show a great liking for it. At Cotot, cattle crossed over native pas-

tures and Paspalum to get to the Para. This was continued until the Para grass was closely grazed.

The cost of planting Para grass was from $3 to $10 per acre, according to the method followed. Broadcasting the stalks cost $3; planting the stalks in furrows 3 feet apart, $3.60; planting stalks 30 to 36 inches each way, $7.20; planting the roots 30 to 36 inches each way, $9.80; and planting roots 3 to 5 feet apart in furrows, $10 per acre. These figures are based on the cost of all the labor of digging and planting the roots, or of cutting and planting the stems, but are exclusive of clearing or plowing the land.

Paspalum dilatatum.—The area planted to Paspalum grass this year was larger than that of any other year. At Cotot and Piti approximately 40 acres were planted from August to December. These plantings were made both on the lowland and on the high rocky hillsides and slopes. No pronounced dry season occurred during the year, and the grass developed to a remarkable degree. The grass on the lowland made a much better growth and more quickly covered the ground than did that planted on top of the hills.

Paspalum costs from $15 to $50 an acre, according to location and labor required to clear and prepare the land. Heavily wooded land at Cotot, after being cleared and burned over and receiving no other preparation, cost an average of $44.55 per acre to place the field in Paspalum. At Piti a field which was covered with only a moderate growth of native grass and brush was prepared and planted to Paspalum roots at the rate of $42.69 per acre. As it was necessary to weed this land twice before the grass was firmly established it cost nearly $50 per acre to put the grass on a basis for pasturing. This was higher than usual, but the increased supply of pasturage shows that it is good practice to establish permanent grazing for live stock. The average farmer no doubt could plant Paspalum much cheaper than the station did, as labor was high at that time and the laborers worked only eight hours a day. The farmer is also able to establish small areas at odd times at very low cost, especially during the rainy season when work can not be done in the other fields.

Pasture tests at Cotot indicate that Para pastures which have been grown by planting the stalk cuttings will stand much more grazing than will the pastures which have been started by strewing the ground with the cuttings. A small trial area was planted to Paspalum by strewing the ground with the stalk cuttings instead of planting the roots or sets as has been the usual practice. Woodland that is cleared and burned off if not planted at once soon grows up to weeds. In such cases the land is generally recleaned with fosiños or hoes at planting time. This year about 6 acres of formerly

cleared woodland, which had grown over with weeds, was planted to Paspalum without either cleaning or hoeing, the sets being planted among the weeds. About 6 acres of Para was also planted in very much the same manner, the only difference being that the cuttings were stuck into the ground instead of being strewn. These areas were not hoed or otherwise cleaned until several months later. At Piti a small area of open hill land was planted to Paspalum without first being cleared of the native grass (*Andropogon aciculatus*). The plat was hoed after about two months. The results of these tests show the advantage of cleaning the ground at planting time. New plants can gain the necessary start over weeds and other growth only when they have a clean seed bed. The plantings should also be cleaned once or twice later on, when they are made on other than newly cleared woodland.

After long and practical experiments with Para and Paspalum at Cotot to ascertain the place these two grasses hold in the general scheme of cattle improvement, it has been definitely concluded that Paspalum should constitute the main pasture on a range with conditions similar to those of Cotot. Para grass is too easily killed by continuous pasturing or the least heavy pasturing during the dry season to be used as the general or chief pasture. There should be sufficient area of Para grass, however, to serve as a supplementary pasture on which occasionally to range cattle which are in thin flesh or off condition, or which are poor milkers with calves at side. Moreover, the area should be sufficient to furnish cut feed for animals which are fed in stalls.

Guinea grass (*Panicum maximum*).—This grass has been growing at Piti and Cotot for many years. The plants were hardy, and they survived and even increased under conditions of neglect. Root divisions of these plants were transplanted to a small trial plat where they have made vigorous growth. This grass will be compared with other grasses and forage plants during the coming year.

Sudan grass (*Andropogon sorghum*).—Work was continued with Sudan grass on a small scale (Pl. III, fig. 1). It made a better growth during the dry season than during the rainy part of the year. Toward the close of the year other trial plats were planted to Sudan, which made a good showing, even though the rains were heavy. It is thought that it will make a good annual forage crop and produce several heavy cuttings during the year.

Guatemala grass (*Tripsacum laxum*).—The two small plants of Guatemala grass which were introduced into Guam in 1918 from the Office of Forage Crop Investigations, United States Department of Agriculture, have made good growth. By frequently dividing

the roots, the station obtained enough material before the end of the year to plant a trial plat. This grass makes rapid growth and has wide, heavy leaves. No feeding tests have been made with it as yet, but it seems to be succulent and should make a good forage if it is cut before becoming too coarse.

Japanese cane (*Saccharum officinarum*).—A trial plat of Japanese cane was started during the last of the year for comparison with Sudan, Guatemala, and Guinea grasses. It started off well and compared favorably with the others at the close of the fiscal year.

Johnson grass (*Andropogon halepensis*).—Johnson grass was introduced into Guam about the time the station was established. Roots for the initial planting at the station were obtained in 1909 from Joaquin Diaz, of Piti, who introduced it from the island of Saipan under the name of Samoa grass. It is said that this grass was brought to Saipan from Samoa, where it had been introduced by the noted writer, Robert Louis Stevenson.

Johnson grass is more of a pest in Guam than it is in the southern part of the United States, because there is no cold weather here to check its growth. Its ability to retain occupation of the soil and spread to adjoining fields, especially to cultivated fields, makes it a very obnoxious weed. It makes a vigorous growth and can be kept in check only by frequent removals or by heavy pasturing. In an area where the roots were pulled up and burned as soon as the plants began to blossom, the growth was gradually lessened. In another area where similar prompt treatment was given, the grass continued to spread. In an area of Johnson grass where pigs were pastured in small movable pens, the grass was apparently killed out. In another place where the roots were dug out a number of times during the past four years, small pieces evidently remained in the ground, because another crop is starting.

No distribution has been made of this grass because of its habit of spreading. Doubtless it would make a good perennial forage plant, but it is thought that it should be planted on some small island in the Pacific where cattle raising is the only industry carried on.

Variety tests.—Several varieties of grass were placed in trial plats during the year for testing as to their adaptability to Guam soils, culture, and forage qualities. A large number of these did not germinate, but a start was made with *Pennisetum setosum*, Jaragua, Guatemala, Napier, Guinea, and Sudan grasses.

SORGHUM (ANDROPOGON SORGHUM).

Conditions were more favorable for grain-sorghum production this year than in the two previous years. Neither extended droughts nor heavy rains occurred during the time the sorghums were in the flow-

ering stage, and, as a result, both seed and forage yields were secured. Rather extensive variety tests and soil-adaptation studies were carried on to determine the variety or varieties of sorghum best adapted to the soil and climate of Guam. As was true in the past, the highest yields were obtained during the dry season. This feature makes sorghum of particular local value, because it produces well at a time when other kinds of forage are scarce.

Grain sorghums.—The grain sorghums are valuable particularly as a forage and as a grain crop. The grain, like corn, can be fed to all classes of live stock, but it is especially well suited as a poultry feed because of the small size of the kernels.

Two plantings, one on newly broken land and the other on old station land, furnished three crops each during the first part of the year, and a light crop due to heavy rains was mature at the end of the year. The planting on newly broken land was made on June 14, 1919. On the old station soil the planting was made June 21, and replanted on July 8, 1919. The crops growing on the new soil averaged 93 days from time of planting or cutting to time of harvesting, while those on the old soil averaged 83 days between crops. The Dwarf hegari kafir was in most cases about 10 days earlier in maturing than were the other varieties. The following table gives the results of the grain sorghum planted on the newly broken land.

Comparison of yields per acre (newly broken land) of first crop and subsequent crops of different varieties of grain sorghum.

Variety.	First crop.		First ratoon.		Second ratoon.		Total.	
	Grain.	Green forage.	Grain.	Green forage.	Grain.	Green forage.	Grain.	Green forage.
	Bushels.	*Tons.*	*Bushels.*	*Tons.*	*Bushels.*	*Tons.*	*Bushels.*	*Tons.*
Dwarf hegari kafir	15.86	11.55	6.72	3.75	17.92	2.33	40.50	17.63
Yellow milo	5.76	14.73	2.39	13.75	13.12	5.28	21.27	33.76
Blackhull kafir	3.84	4.48	.....	13.96	2.56	3.76	6.40	22.20
Feterita	6.40	3.04	7.04	10.95	29.44	7.16	42.88	21.15
White milo	3.30	5.74	.....	10.27	13.44	7.07	16.74	23.08

In this test the milos gave the highest yield of green forage, and feterita, closely followed by Dwarf hegari kafir, gave the largest yield of grain. Grain yields in all the tests were greatly reduced by domestic pigeons kept on a neighboring ranch. The white-grain varieties, especially Blackhull kafir, usually suffer more from these attacks than do the colored varieties.

The results of the grain sorghum test on the old land are given in the following table:

Comparison of yields per acre (old land) of first crop and subsequent ratoon crops of different varieties of grain sorghum.

Variety.	First crop.		First ratoon.		Second ratoon.		Total yield.	
	Grain.	Green forage.	Grain.	Green forage.	Grain.	Green forage.	Grain.	Green forage.
	Bushels.	*Tons.*	*Bushels.*	*Tons.*	*Bushels.*	*Tons.*	*Bushels.*	*Tons.*
Darso [1]	4.71	6.60	.....	3.12	4.71	3.52	9.42	13.24
Brown kaoliang [1]	14.14	5.54	.....	5.19	4.71	3.34	18.85	14.07
Dawn kafir [1]	3.14	.40	.....	5.72	11.00	2.33	14.14	8.45
Schrock kafir [2]	8.64	5.77	.....	5.13	11.00	4.45	19.64	15.35
Yellow milo [2]	28.28	6.65	3.93	6.98	13.75	3.59	45.96	17.22
Dwarf hegari kafir [2]	36.14	6.85	18.85	9.20	46.34	3.94	101.33	19.99
Blackhull kafir [2]	13.62	3.20	.....	7.32	13.09	5.49	26.71	16.01
White milo	7.85	7.88	.....	5.90	14.14	5.37	21.99	19.15
Feterita	25.14	4.58	5.86	6.20	19.64	4.40	50.64	15.18
Whitehull kafir	7.86	2.90	.....	5.94	5.40	3.90	13.26	12.80
White kafir	6.28	2.42	.....	4.71	11.00	1.76	17.28	8.89

[1] Very poor stand. [2] Average of two or more plats.

The most noteworthy thing about this test was the high yield in grain of the Dwarf hegari kafir, which was more than twice as much as the next highest yielding variety, feterita. However, these two varieties had a slightly better stand than did the others, which probably accounts to some extent for the difference in yields. Dwarf hegari kafir and white milo gave the highest yields of forage, while Dawn and White kafir gave the lowest yields. The absence of grain yields in most varieties in the first ratoon crop was probably caused by the heavy rains which fell at flowering time and before the plants had an opportunity to become pollinated. Yellow milo, feterita, and Dwarf hegari kafir blossomed a few days before the rain started and enough blossoms were fertilized to produce some seed. In nearly all cases the quantity of seed produced in the sorghum tests was in indirect proportion to the volume of rain falling at the time the plants were in the flowering stage.

Other grain-sorghum tests were made during the year, but no results have as yet been obtained from them. Sudan grass, when planted with the regular plantings, failed to germinate.

Broom corn on the newly broken land yielded at the rate of 37.76 bushels of seed and 8.50 tons of coarse green forage per acre during the year. A very poor stand was secured on the old ground. The brush was of very poor quality on most plants, owing to poor exsertion and molding where the head had not pushed entirely out of the boot.

A test was made on January 20, 1920, to determine the cost of planting milo and kafir. The cost of plowing per acre was $6.25; for harrowing, $1.08; for laying out rows, $1.08; and for planting

the seed, $1.03, making the total cost per acre $9.44. This is much less than is ordinarily charged. The average cost of the first crop yield of milo and kafir from the old soil planting would be $0.466 per bushel for preparing and seeding the land. This would not include the cost of cultivation and harvesting. The cost could be reduced, of course, were successive ratoon crops grown.

Sweet sorghums.—Sweet sorghums do well in Guam and produce large quantities of forage as well as grain. The grain is used to a certain extent for feeding chickens, but is not nearly as good as that of the grain sorghums. The forage is readily eaten by the animals at the station and is considered a fairly good feed. However, it is not as good as Para or Sudan grass, because it is coarser and contains a larger percentage of waste. The following table gives the results of the first cutting and the two ratoon crops from the same plantings:

Yield per acre of different varieties of sweet sorghum.

Variety.	First crop.		First ratoon.		Second ratoon.		Total yield.	
	Grain.	Green forage.	Grain.	Green forage.	Grain.	Green forage.	Grain.	Green forage.
	Bushels.	*Tons.*	*Bushels.*	*Tons.*	*Bushels.*	*Tons.*	*Bushels.*	*Tons.*
Red Amber [1]	9.60	7.43	12.80	18.80	24.96	10.20	47.36	36.43
Orange [1]	3.84	5.37	3.84	10.94	4.48	1.61	12.16	17.92
Black Amber [1]	20.48	9.31	.....	15.11	16.00	10.20	36.48	34.62
Orange [1]	4.12	2.41	.....	2.90	10.58	2.48	14.70	7.79
Honey	.....	.75	.....	.48	.....	.22	.....	1.45
Black Amber [1]	17.28	6.12	.....	5.54	25.92	5.76	43.20	17.42
Red Amber [1]	4.71	10.12	.....	6.25	14.14	3.74	18.85	20.11
Red Sorgho	.....	.....	.....	2.07	.....	.53	.....	2.60

[1] Two plats of each.

The first three varieties listed were grown on the newly broken land and the remainder on the old soil. The crop which was planted on new soil on June 14 was cut for the first time on October 6, 1919. The first ratoon crop was harvested on December 3, 1919, and the second ratoon crop was cut on March 24, 1920. The crop which was planted on the old soil on June 21, and replanted on July 8, 1919, was first harvested on October 26. The first ratoon crop was harvested on January 2, and the second ratoon crop was cut on March 23, 1920. It is thought that the yield from the third ratoon crop, which was ready for cutting at the close of the year, would equal the average production from the three previous cuttings.

The Honey and Red Sorgho varieties were almost failures, the stand being not more than 5 per cent over a normal crop. The Amber varieties gave the best results in all the tests made at this station and seem well adapted to local conditions.

LEGUMES.

Special emphasis was again placed upon the growing of legumes, and a much more extensive area was devoted to the crop than was the case last year. The results obtained after a long period of trial have been so satisfactory that the station advocates the use of legumes as cover crops to keep down weeds, as soil builders when turned under as green manure, and as forage for animals when the vines are cut in the green stage. The beans can be used for food, both in the green-cut and dry state, or as concentrates for live stock.

The cowpea and velvet bean received particular attention, variety tests and soil trials being made with both these legumes. Other tests are under way to find the best legumes to grow for cover crops, forage, grain production, and food use under Guam soil and climatic conditions. The demand for leguminous seeds, especially of edible varieties, is gradually increasing, and some of the more progressive farmers are recognizing the importance of planting larger areas to cover crops.

Cover crops.—Cowpeas, velvet beans, and jack beans were successfully grown in the citrus orchard as cover crops. The Whippoorwill cowpea, which matures in about 90 days is sufficient for a short time. Other varieties now under test make better cover crops. Of all the cover crops the velvet bean is the most efficient, because it quickly covers the ground. However, it must be cut back in the orchard or plantation, or it will climb the trees. The jack bean matures late, and must be planted fairly close to smother out the weeds.

Extensive cooperative tests were carried on with cowpeas, velvet beans, jack beans, and Patani beans (*Phaseolus lunatus*) in a large coconut plantation at Tarague. Regular acre-sized plats were maintained for comparison, and large plantings were made in other parts of the plantation. At the end of the year 25 acres were covered with a dense growth of Patani bean vines which were keeping down the underbrush, as well as the grass and weeds, in a most satisfactory manner. Forty more acres in the plantation were cleared and prepared for planting as soon as seed could be obtained. Additional areas were being prepared for cover crops which have fully demonstrated their value in keeping down weeds. It is planned to plant at least 400 acres of coconut plantation to cover crops as soon as seed is available and the underbrush can be slashed. Cover crops were planted on waste land at the station and on land which was not wanted at the time for planting to other crops. It was found less expensive to grow cover crops on such lands than to let them grow to weeds which would have to be removed later. The practice is

also beneficial in that the crop can be used for forage, green manure, to secure seed for distribution, or to furnish feed for live stock.

Green manure.—Experiments in green manuring were continued. In field plats where successive crops of cowpeas had been turned under, the soil showed a marked difference from those of plats not so treated. The ground which received the green manure was loose, mellow, and much more easily cultivated, and the soil did not dry out, compact, and crack during the dry season, nor run together and puddle during the wet season. In the pot experiments, soil which had received an application of green manure at the rate of 5 tons per acre preceding each corn crop gave much higher yields than soil in pots not receiving green manure. Moreover, the treated soils were among the highest yielding of a large series used in fertilizer tests in pots.

Legume inoculation.—An examination of legumes growing at the station farm showed that nearly every variety was provided with nitrogen-fixing bacteria. Those showing the presence of bacteria by the formation of nodules included cowpeas, velvet beans, mungo beans, peanuts, rice beans, adzuki beans, and soy beans.

Cowpeas (Vigna sinensis).—The greater part of the cowpea area at the station (exclusive of the variety tests) was again planted to the Whippoorwill variety. In a planting made on August 8 and harvested on November 5 and 26, an area of 0.545 acre yielded 338.5 pounds, or at the rate of 10.35 bushels to the acre. Other plantings were made on June 19, November 13, December 15, and December 27 and used as forage for live stock. The plantings of June, while severely attacked by grasshoppers, gave fairly good yields.

Four variety tests were conducted during the latter half of 1919 to determine the difference in yield of cowpeas planted on old soil and on newly broken land. The following table gives the results of the tests:

Effect of date of planting on maturity and yield of different varieties of cowpeas.

Date of planting and variety.	Date blossomed.	Date first pods matured.	Date harvested.	Length of vine.	Yield per plat.		Yield per acre.	
					Seed.	Green forage.	Seed.	Green forage.
Planted on old soil June 19, 1919:				*Feet.*	*Pounds.*	*Pounds.*	*Bushels.*	*Tons.*
Whippoorwill	Aug. 21	Sept. 23	Dec. 16	6.95	(1)	[2] 180	.....	[2] 2.03
New Era	Aug. 13	Aug. 26	...do....	8.55	(1)	605	.....	13.56
Early Buff	Aug. 1	Aug. 18	...do....	1.89	(1)	325	.....	7.28
Iron	Sept. 23	Oct. 20	...do....	9.35	(1)	539	.....	12.08
Large Blackeye	Aug. 8	Aug. 21	...do....	8.31	(1)	475	.....	11.64
Groit	Aug. 18	Sept. 2	...do....	6.06	(1)	451	.....	10.10
Brabham	Aug. 16	...do....	...do....	9.37	(1)	683	.....	15.30
Planted on old soil Dec. 20, 1919:								
Whippoorwill	Feb. 4	Feb. 20	Mar. 13	6.03	12.8	385	7.45	6.55
New Era	Feb. 6	Feb. 28	...do....	7.15	14.0	544	8.14	9.25
Early Buff	...do....	Feb. 18	...do....	3.42	2.0	137	1.16	2.33
Iron	Feb. 13	Feb. 16	...do....	5.67	5.0	242	2.91	4.11
Large Blackeye	Feb. 2	Feb. 26	...do....	7.65	2.5	[3] 70	1.45	[3] 1.19
Groit	Feb. 6	...do....	...do....	4.63	11.0	398	6.39	6.77
Brabham	Feb. 8	...do....	...do....	5.58	16.0	306	9.31	5.20
Red	Feb. 10	...do....	...do....	4.59	[4] 4.0	[4] 61	2.33	4.15
Planted on newly broken land July 8, 1919:								
Whippoorwill	Sept. 23	Oct. 7	Nov. 5	7.10	99.0	981	15.49	4.61
New Era	Sept. 8	Sept. 18	Nov. 6	5.31	125.0	1,044	19.56	4.90
Early Buff	Sept. 2	Sept. 10	Oct. 27	3.39	32.0	214	5.01	1.00
Iron	Sept. 23	Oct. 3	Nov. 6	7.00	100.5	1,321	15.73	6.20
Large Blackeye	Aug. 26	Sept. 18	...do....	8.18	68.0	411	10.64	1.93
Groit	Sept. 3	Sept. 19	Nov. 7	6.21	110.5	1,219	17.24	5.72
Brabham	Sept. 18	Sept. 24	Nov. 6	6.74	96.0	1,698	15.02	7.98
Planted on newly broken land Nov. 29, 1919:								
Whippoorwill	Jan. 8	Jan. 30	Feb. 19	7.13	26.5	(5)	4.15	(5)
New Era	Jan. 3	Jan. 23	Feb. 18	8.33	53.5	(5)	8.37	(5)
Early Buff	...do....	Jan. 18	Feb. 7	3.37	22.0	(5)	3.44	(5)
Iron	Jan. 11	Jan. 23	Feb. 18	10.02	30.5	(5)	4.77	(5)
Large Blackeye	Jan. 3	...do....	Feb. 19	7.95	16.0	(5)	2.50	(5)
Groit	Jan. 6	Jan. 26	Feb. 17	8.92	57.0	(5)	8.92	(5)
Brabham	Jan. 3	Jan. 25	Feb. 18	7.20	20.0	(5)	3.13	(5)
Red	Jan. 6	Jan. 26	Feb. 17	7.88	41.0	(5)	6.42	(5)

[1] No seed harvested on account of insects and wet weather.
[2] Yield greatly reduced by stray animals getting into plat.
[3] Poor stand.
[4] One-fourth area of other plats.
[5] Plowed under for green manure.

The average results obtained in these four tests show that the New Era cowpea gave the highest yield of seed and that Brabham gave the highest yield of forage. The highest yields in any test were 19.56 bushels of seed and 15.30 tons of green forage, which were made by the same varieties giving the highest average yield in the four tests. The Early Buff variety matured the first pods on an average of 5 days earlier than the Red variety, which was next, and 21 days earlier than the Iron variety, which was the latest maturing. A large field test was again made on newly broken land on May 21. The Victor cowpea was added to the eight varieties formerly tested, and all varieties had covered the ground at the close of the fiscal year. A small plat variety test was begun on May 22, on old soil. The Early Buff and New Era varieties had blossomed before the close of the year. Some of the varieties were very much infested with aphids.

These, however, were washed off when the heavy rains started, and the plants quickly recovered.

Velvet beans (*Stizolobium* spp.).—A large number of variety tests were conducted with velvet beans at different times during the year. This legume, which can be used for stock feed, or as a green-manure and cover crop, has been found to be one of the most valuable crops of the station. The vines remain green, even when large quantities of grain have been taken from them, and they can be plowed under while in a succulent condition, in which stage they rapidly decompose in the soil. Velvet beans do well at all seasons of the year, but their yield was greater at this station when they were planted so that the beans could mature during the dry season. Accurate record of seed yield was obtained from only three tests, one test being discontinued so that the field could be used for small experiments before the late-maturing varieties produced much seed. Another of the velvet bean plats was still producing at the end of the year. The following table gives the results of the three tests:

Effect of date of planting on maturity and yield of different varieties of velvet beans.

Date of planting and variety.	Date blossomed.	Date first pods matured.	Date harvested.	Length of vine.	Yield of seed.	
					Per plat.	Per acre.
Planted on newly broken land July 10, 1919:				*Feet.*	*Pounds.*	*Bushels.*
Black Mauritius	Nov. 6	Jan. 20	Mar. 2	10.77	385.5	67.81
Georgia	Sept. 4	Nov. 15	Dec. 15	9.38	295.0	51.89
100 Day Speckled	Sept. 2	...do....	Dec. 16	6.30	209.0	36.76
Osceola	Sept. 11	Nov. 17	...do....	10.61	[1] 189.0	66.50
Alabama	Sept. 8	Nov. 15	Dec. 15	9.35	150.5	26.47
Yokohama	Sept. 23	Nov. 20	Dec. 16	8.80	[2] 72.0	101.28
Planted on newly broken land Jan. 20, 1920:[3]						
Alabama	Mar. 25	May 5	June 28	.....	91	7.98
Georgia	Mar. 27	...do....	June 29	.....	176	15.43
100 Day Speckled	Mar. 23	...do....	...do....	.....	40	3.50
Osceola	May 1	May 30	June 30	.....	95	8.33
Yokohama	Apr. 26	May 28	...do....	.....	203	17.80
Lyon	Apr. 29	June 1	...do....	.....	4	1.40
Planted on old soil Dec. 29, 1919:[4]						
Alabama	Mar. 30	Apr. 12	Apr. 20	.....	133.0	27.70
Georgia	Mar. 27	Apr. 15	...do....	.....	118.0	24.58
Yokohama	Apr. 2	Apr. 12	...do....	.....	173.0	36.04
100 Day Speckled	Mar. 20	...do....	...do....	.....	91.0	18.95
Lyon	Mar. 31	May 7	June 20	.....	6.5	1.35
Osceola	Mar. 31	.....	...do....	.....	5.0	1.04

[1] Only 4 rows in plat. (Standard plats are 24 by 172 feet, and each contains 8 rows.)
[2] Only 1 row harvested.
[3] Still producing at the end of the year.
[4] Test discontinued before finished and vines plowed under.

It will be noted that the early maturing varieties gave the smallest yields, and that of these the Georgia gave the highest, producing in one test at the rate of 51.89 bushels of seed to the acre. The Yokohama is a medium-early maturing variety, averaging 132 days from time of planting until the first pods are produced. The Osceola is a medium-late maturing variety and the Black Mauritius is a

very late variety. The early varieties mature all their fruit in a very short time after the pods begin to ripen, while the late varieties ripen over a more extended period. The late varieties make better cover crops for long periods than do the early varieties.

During the last part of the year two tests, each including seven varieties, were made with velvet beans, the plants being placed between rows in a corn and kafir field after the crops were nearly mature. These varieties gave less promise than did the varieties planted in the open. The varieties Bush, Chinese, and Florida were also planted for comparative purposes in field A. The Bush variety gives every promise of being a good one for citrus orchards, or for other fruit trees, because it does not climb upon the trees.

Pigeon peas (*Cajanus indicus*).—This crop was tested at the station to determine the best variety for forage, windbreaks, and grain production. The green peas are used as a substitute for the sugar or English pea and are very much liked. The dry peas are also used for food. On May 22 a variety test was carried on with seed from Vincent (dark red, a selection made at this station), Columbia, British West Indies, New Era (selected for grain yields), New Era (selected for forage yields) from Hawaii, and the native variety. All were making good growth at the end of the year with the exception of the New Era (selected for forage yields), which did not germinate. Some plantings were made around the citrus orchard for windbreaks, and more extensive plantings were made on a heavy clay sidehill. All were about eight feet high and making vigorous growth at the close of the year.

Patani beans (*Phaseolus lunatus, mixed*).—In these tests the beans were planted the last of November and the first of December, but owing to heavy rains at flowering time the yields of seed were very low. Results of tests with Patani beans at Tarague showed them to be efficient cover crops, occupying the ground well over a year, and in some case more than two years, from a single planting. More extensive tests will be made to determine fully their value, not only as a cover crop, but also as a forage crop.

Small-bean test.—On May 22 a test was begun in field A with native mungo, Hawaiian mungo, green mung, black mung (all varieties of *Phaseolus aureus*), urd (*P. mungo*), Patani, two varieties of rice bean (*P. calcaratus*), and three kinds of adzuki beans (*P. angularis*). A good stand was secured in all plats, the native and Hawaiian mungo beans being larger and of a more upright growth than were the other varieties.

Native varieties of beans.—A number of native varieties which had never been tested for yield or effectiveness as cover crops were collected and planted in a series of trial plats on June 5. These varie-

ties are locally known as White Cerebilla, Red Cerebilla, Judias, Chochomeco, Seguidillas, and Acangcang-tase. Most of them had germinated and started growth before the end of June.

Soy beans (*Glycine soja* or *Soja max*).—Several attempts have been made to grow soy beans on this island, but none has been very successful so far. In May the varieties Mammoth Yellow, Laredo, Hahto, Tokyo, Haberlandt, Virginia, Biloxi, and Barchett were planted in well-prepared seed beds. Pigeons and chickens belonging to neighboring farms made it almost impossible to secure a good stand from these plantings, although in some instances they were made four times. All of the varieties, with the exception of Biloxi and Barchett, finally made poor stands.

Peanuts (*Arachis hypogæa*).—This plant is not grown extensively on the island, but is suited to certain places where the soil is of a sandy nature. A variety test was made with 10 varieties of peanuts, but only three of the Guam-grown varieties germinated.

Mungo beans (*Phaseolus aureus*).—This bean vine makes an upright, branching growth, reaching an average height of 30 to 36 inches. The leaves are fairly large. The beans are highly prized by the Chamorro people as food. They mature very unevenly and must be harvested promptly and frequently on account of their tendency to shatter. The pods are round, slender, and rather small, being from 3 to 4 inches long. They make a fairly good cover crop during short periods, because they mature seed in about 60 days. After this time the leaves drop off, and their effectiveness rapidly diminishes. They are used to a considerable extent in the chicken runs, papaya orchards, and pineapple fields. After they have produced just enough seed for future plantings they are turned under as green manure while the orchard is being cultivated.

Bur clover (*Medicago hispida*).—This legume was introduced into Guam by this station during the year. California or toothed-bur clover was planted in June. The stand was good, but at the end of the year it had been greatly reduced by heavy rains, which caused many of the plants to die after they put out three or more leaves. Clovers have given unsatisfactory results in all former tests, but more trials will be made during the coming year to determine if the bur clover can be established in Guam.

ROOT CROPS.

The area planted to root crops was increased during the year to furnish feed for live stock. A test was made to determine the most suitable varieties for Guam, and the crops grown on a good-sized basis included taro, cassava, sweet potatoes, arrowroot, and edible canna. Some data were obtained as to the value of these crops for

human consumption as well as for feed for live stock. The roots were dried in most cases before they were fed to the animals. This was necessary to keep large supplies for any length of time, as the crops were harvested in considerable quantities. A number of the crops in the larger tests matured, but owing to labor conditions it was impossible to harvest them before the close of the year.

Taro (*Colocasia esculenta*).—For years the taro plant, locally known as suni, has furnished food for millions of people in the Tropics, but it is only comparatively recently that American and European people have become interested in this crop. The general practice of the Chamorro farmer is to plant taro, together with bananas or plantains, on all newly cleared land. Seven varieties of taro (one is probably a yautia, *Xanthosoma* sp.) grow on the island, and to these the station has added three more. These are the dasheen, a Japanese variety, and an imported one from which the label was lost. The latter variety is locally called the "American" taro, but it is probably a yautia. The dasheen and Japanese variety have not been grown in sufficient quantity to include in any of the field tests carried on at this station. Most of the varieties have been growing on the island for a long time, and some are said to have grown here before the discovery of the island by Magellan. The tubers are the most important part of the plant, but the leaves and stems are also used as food. The tubers are used in many ways as potatoes are used in the Temperate Zone. The young leaves are cooked in very much the same manner that spinach is cooked. The older leaves and stems, and to some extent the tubers, are commonly fed in a cooked state to swine. The roots of the taro are peeled before drying if they are to be kept indefinitely for human consumption, but they are left in the natural state for live stock. The tubers are sliced in thin pieces, dried in the sun for a day or so, and then stored in moisture-proof tanks until they are needed.

Land crabs and poor soil conditions interfered to a considerable extent with the production of taro during the past year. However, a large supply of feed was secured, and a sufficient number of young plants were obtained to start a more comprehensive test where the taro will not be affected by droughts and pests. After producing the young suckers, the older plants were harvested on March 2, 1920. The variety Pacencia yielded at the rate of 3,314.7 pounds to the acre; Visaya yielded 2,094.6 pounds; Apaca, 833.8 pounds; Manila, 584.1 pounds; and Agrigan, 292 pounds. Only the mature taro was harvested, and a good stand of young plants was left.

Toward the close of the year a test was started to determine the best variety to grow under different Guam conditions. The test crop was planted in duplicate, one part being on upland, and the other on lowland which can be flooded. Some doubt exists as to which

varieties are better adapted to upland and which to irrigated locations. The Visaya and the Pacencia varieties are generally considered better adapted to lowlands, although the Visaya is also largely planted on the higher land. There is also some question as to which varieties are less subject to root-rot, especially when planted in the lowlands. It was principally to determine these facts that the tests were undertaken.

Cassava (*Manihot manihot* or *M. utilissima.*)—Several plantings of cassava, locally known as mendioca, were made during the year. The rate of yield ranged from 4,161.9 to 15,630.8 pounds per acre. In one test by native methods for starch, 481 pounds of fresh cassava yielded 32 pounds, or 6.65 per cent, of dry starch. The yield was said to be greatly reduced because of the woody condition of the plants, which were past maturity. In another test a yield was secured of 10.63 per cent of dry starch. The starch is used in many ways for food purposes, and the root is used as a vegetable and as a feed for live stock. On account of the ease with which it can be propagated and its large yields, the cassava is found growing in nearly every garden in Guam, and it is the principal starch plant of the island.

Very little attempt has been made to classify cassava into varieties. As a general rule it is divided into bitter and sweet varieties, depending largely upon the amount of hydrocyanic acid the plant contains. There is little or no distinguishing character in the vegetative portion of the plant. Three distinct types have been separated and planted for further testing at the station. These are the Amarillo (yellow), the Apaca (white) or Saipan, and the Guam or native mendioca. The leaves of all are so nearly alike that they can not be distinguished from one another. However, the plants have certain other vegetative differences, and the native people recognize a difference in the edible qualities of each kind. In the Amarillo variety the roots are short, thick, and bunched, the skin or covering is dark brown, and the interior is a decided yellow. This variety is used for food much the same as the sweet potato, and while it is still tender it tastes like one. Apparently no ill effects have resulted from eating this type. The Apaca variety is said to have been introduced from the island of Saipan. The roots are long, slender, and more spreading than either of the other varieties. The outside of the root is light in color, the inside skin is pale pink, and the inside of the root is pure white and has a very starchy taste. It is preferred for making starch, and is used as a vegetable only after it has been well cooked. The Guam variety is said to be a native of this island. The roots are a darker brown than those of the yellow cassava and resemble them in shape and clustering habit, but are larger when fully mature. The dark-red color of the inside skin of the freshly dug root is the

distinguishing characteristic of this variety. The inside of the root is white, starchy, and very crisp.

No injurious effects have been noted to follow the feeding of cassava to live stock, but in some instances people have died from eating it. Death occurs supposedly from the small amounts of hydrocyanic (prussic) acid present in the roots. So far as the writer has been able to learn, no poisoning has developed where the cassava was thoroughly cooked or dried before being eaten. As hydrocyanic acid is highly volatile, it is probably broken up or driven off by the action of the heat. During the past year a child in Agaña died from what was reported as cassava poisoning. Investigation showed that the cassava had been only partly cooked, and an autopsy showed the stomach to contain large hard pieces of cassava, although the child did not die until six hours after eating it. No information could be given as to the variety eaten, because the cassava had been bought in the market and none of the root remained. Five other members of the family had partaken of the cassava, which was the only food eaten at the time, yet not one of them suffered injurious effects from it.

Arrowroot (*Maranta arundinacea*).—This plant is commonly grown in Guam. The roots are used for making a starch, which is of very good quality, and is largely used for making cakes and other pastry. In a planting of arrowroot made on a heavy clay and rocky soil on January 9, 1919, and harvested on January 3, 1920, the yield was at the rate of 3,123.1 pounds per acre. Two hundred pounds of roots yielded 22 pounds of high-grade starch. The yield would have been greater had the roots been harvested as soon as the plants matured. In another test a yield of 6½ pounds, or 13 per cent, of dry starch was obtained from 50 pounds of dry roots. This starch was extracted by the native methods, which are very crude. Another planting on the same ground was made on January 7, 1920, and was ready for harvesting at the end of the year.

Edible canna (*Canna edulis*).—A field test of edible canna yielded 1,025 pounds to the plat, or at the average rate of 14,073 pounds to the acre, one year after planting. Another field test was begun on March 2, 1920. Edible canna is planted in rows 3 feet apart in the field, and the plants are spaced 3 feet apart. The young bulbs are used in planting.

Sweet potatoes (*Ipomœa batatas*).—Although this crop is rather widely grown upon the island, the different varieties have received very little attention. During the year the station tested six of these varieties to determine their value as food and as a local feed ration for the station animals. The roots were harvested as soon as they matured or fully developed to prevent them from being tunneled by the sweet-potato weevils (*Cylas formicarius* and *Euscepes* (*Crypto-*

FIG. 1.—SUDAN GRASS.

FIG. 2.—KAPOK TREES PLANTED FOR LIVING FENCE POSTS.

FIG. 1.—NATIVE METHOD OF PREPARING LAND FOR CORN.

FIG. 2.—CORN PLANTING EXPERIMENT. AVERAGE STALKS FROM PLATS WITH 1 TO 6 STALKS PER HILL.

rhynchus) *batatæ*). When a larger supply was harvested than could be used before they rotted, the tubers were cut into thin slices and dried in the sun for one or two days, depending upon the amount of sunshine and the condition of the roots. After drying, the pieces were placed in storage tanks where they kept in good condition, and later they were fed to swine. The following table gives the yield from sweet-potato cuttings which were taken from the station plats and planted on a heavy soil at the beginning of the rainy season (July 9, 1919).

Results of sweet-potato variety test.

Name.	Date harvested.	Yield per plat.		Yield per acre.		
		First test.	Second test.	First test.	Second test.	Average.
	1920.	*Pounds.*	*Pounds.*	*Bushels.*[1]	*Bushels.*[1]	*Bushels.*[1]
Amarillo	Feb. 21	146.0	49	54.4	38.6	46.5
Yap	...do....	108.0	44	40.3	34.7	37.5
Peru	...do....	186.0	21	69.4	16.5	43.0
Patas Nganga	Feb. 23	83.0	22	31.0	17.3	24.2
Amarillo	Feb. 25	73.0	122	27.2	96.2	61.7
American	...do....	124.0	86	46.1	59.6	52.9
Dago	Feb. 26	13.5	12	7.6	23.6	15.6

[1] Bushel equals 55 pounds.

Sweet potatoes usually mature in less time than did those in these tests. The yields were at the rate of 7.6 to 96.2 bushels per acre. The Amarillo, or yellow variety, gave the highest yield, closely followed by an imported American variety, while the Dago variety gave the lowest yield.

On January 14, 1920, one-fourth acre was planted to sweet potatoes which were hogged-off at harvest time. In this test the cost of preparing the soil and planting was $6.31 per acre for plowing, $3.99 for disking the ground, and $1.44 for planting, or a total of $11.74 per acre for the field.

COTTON (GOSSYPIUM SP.).

The area devoted to cotton was smaller this year than in former years. The variety test started on June 17, 1919, and mentioned in last year's annual report,[1] was partly restarted on July 8, 1919. Heavy winds and rains during the entire growing season and continuous wet weather during the fruiting season greatly reduced the yields and caused much of the cotton to be lost.

The varieties tested included Trice, Express, Wanamaker, Cleveland, Foster, Mebane Triumph, Lone Star, Columbia, and Cook. Cleveland and Express gave the highest yields, the former producing

[1] Guam Sta. Rpt. 1919, p. 31.

401.12 pounds of seed cotton per acre, and the latter 394.38 pounds. Trice made the lowest yield, 217.27 pounds. A cotton which has been growing on the island for years in a wild state and apparently is of Sea Island origin was included in the test. It yielded at the rate of only 85.2 pounds of cotton to the acre. This variety matured the first bolls 11 months after planting. Although these yields are known to be much less than did actually mature, they are believed to be comparative. However, the yields were also much lower than those of former years with other varieties, including the Egyptian cottons.

Heavy rains throughout the wet season made it impossible to obtain any lint. For this reason the stalks were cut back on June 21 to within a foot of the ground for ratoon crops to furnish fresh seed for planting at the beginning of the dry season. This was necessary because it is difficult to keep the seed in a viable condition until the next time of planting.

KAPOK (CEIBA PENTANDRA).

Kapok, locally known as "Algodon de Manila" (Manila cotton) has been grown at the station almost since its establishment. The tree is tall, has a straight trunk, and a few horizontal limbs. The trees blossom each year at the end of the rainy season and bear pods during the dry season. The pods contain a weak silky floss, or fiber, which is used in Guam for making pillows, mattresses, and cushions, and in other places for making life-savers, boat cushions, mattresses, and tapestry. The floss or lint absorbs water very slowly and does not become matted.

The first trees grown at the station were planted along the roadside and were used as fence posts before they were two years old (Pl. III, fig. 2). The destructive typhoon of 1918 slightly injured the lower part of the trunks, but the trees quickly recovered. They have given much satisfaction as fence posts, and a number of new seedlings have been transplanted along many of the station fences. Provided they receive proper care, many of the trees will be large enough to carry some of the wire fencing one year after being transplanted, and they will begin to produce lint and be strong enough to carry the entire fence at the end of two years. As the trees grow tall and straight, with few branches and sparse foliage, and during the greater part of the year have no leaves at all, they shade very little of the surrounding ground. The trees can be planted as close as 10 feet without injury. In this climate most wooden posts decay rapidly, are costly, and are difficult to get. The ground on the lowland becomes soaked to such an extent during the rainy season that the corner posts, no matter how well they are braced, give and permit the fence to sag. For these reasons a growing fence post is of

especial value. The kapok should be extensively grown by the live-stock rancher.

The 2,000 seedlings which were grown in the nursery were ready for use and distribution at the end of the year.

It would hardly be profitable to grow kapok lint on a commercial scale in Guam, because the tree is a low yielder. Results obtained during the last season showed that it cost 33.17 cents a pound to pick and separate the pods, seed, and lint by hand. On account of the need of less costly and more lasting fence posts than are now commonly used in Guam, the station strongly emphasizes the use of the kapok for permanent fences, and of the lint for such local purposes as the farmer may find.

CORN (ZEA MAYS).

Work with corn was continued along lines reported in previous years. Several corn tests dealing with rate of planting (Pl. IV, fig. 1), varieties, and breeding work were conducted during the year. Particular attention was given to rate of planting, because it is thought that the native farmers plant too thick or at least do not thin to the proper stand (Pl. IV, fig. 2). Some preliminary experimental work was begun to demonstrate the value of the use of tillage implements.

The second corn crop of the year (harvested during the fourth quarter of the fiscal year) was a very satisfactory one, both at the station and on the island as a whole. Prices, however, covered a wider range than is usual and reached the extraordinarily high mark of $7 per tinaja (approximately $4.90 per bushel). Corn usually sells around $3 a tinaja (about $2.10 a bushel). This vast difference in price was caused by the greatly increased price of imported food and the shortage of rice on the island. Corn was substituted for other food products or was exchanged for them.

Rate of yield in planting tests.—Planting tests made during the year showed that the yields ranged from 18.62 to 32.48 bushels of corn to the acre in the first test; from 23.70 to 46.05 bushels in the second test; and from 30.37 to 58.02 bushels in the third test. The results of the third test are given in the following table.

Results obtained with corn in planting test.

Number of stalks to a hill.	Average height of stalks.	Average circumference.	Yield.		Number of stalks to a hill.	Average height of stalks.	Average circumference.	Yield.	
			Per plat.	Per acre.				Per plat.	Per acre.
	Inches.	*Inches.*	*Pounds.*	*Bushels.*		*Inches.*	*Inches.*	*Pounds.*	*Bushels.*
1	101.30	4.53	123	30.37	4	90.16	2.72	124	30.62
2	104.96	3.50	233	58.02	5	82.14	2.41	135	33.18
3	99.66	3.46	219	54.07	6	81.12	2.31	126	31.11

This test was begun on March 22, 1920, and the plants were thinned to the required number of stalks to a hill when they were less than one foot high (Pl. V, figs. 1 and 2). On June 25 they were broken over to hasten maturity, and on July 13, or 122 days after planting, they were harvested. A great difference was noticeable in each of the three tests which, on account of their being in close proximity to the Piti-Sumay road, where the traffic is fairly heavy, served as excellent demonstrations to the Chamorro farmer. Many farmers visited the station plats and were much impressed with the results of the tests. The best comparisons were made when the corn was husked and piled in separate lots from each plat. Ears from plats having one, two, and three stalks to a hill were much larger and better filled than those from the other plats. A larger quantity of corn was obtained from the plats having two and three stalks to a hill than from the other plats. An adjoining plat was planted in the ordinary native manner for comparative purposes. This plat yielded 41.51 bushels, which was 28.46 per cent less than where only two stalks were left in a hill, and 23.23 per cent less than where three stalks were left in a hill. The results obtained during the year were not conclusive, but they tend to show that corn when properly thinned will produce more grain than when grown as thickly as it is usually planted by the Chamorros.

Variety tests.—Very little attention was given to variety work, and only one test, consisting of three varieties, was completed. Guam corn was found superior to other varieties under test. A red corn, the seed of which was obtained at Inarajan, and a small yellow variety received from the Hawaii Experiment Station under the name of New Era Bantam Yellow Flint poultry corn, were included with the Guam white corn. The red corn is evidently a mixture from a cross made between the Guam corn and the St. Vincent corn which was grown at this station many years ago. It gave poor germination, and later much of it was drowned out by heavy rains. The small yellow variety did fairly well and matured early, but because the ears develop close to the ground it was greatly damaged by rats and chickens.

Breeding work.—Ear-to-row tests were conducted by the station for number of rows or kernels to ear and a high-yielding strain irrespective of other characters. These were in addition to the regular ear-to-row test that has been in progress for the last 10 crop seasons. Second-generation seed was used in the first two tests, but was killed by heavy continuous rains. Plantings were then made for the third time, and the tests were restarted.

Studies of number of rows of kernels to ear.—Selections were again made from the breeding plants for number of rows of kernels to ear. As was true in former tests, the 10-row ears were the most dominant

in the progeny from the general field selections and from the 10-row, the 12-row, and the 14-row parent ears. Examinations were made of progeny of 1,052 ears from the general field selection, 993 ears from the 10-row selections, 937 ears from the 12-row selections, and 235 ears from the 14-row selections. The progeny with 10 rows of kernels to the ear occurred in 75.85 per cent, 64.65 per cent, 72.04 per cent, and 53.61 per cent, respectively. The rate of yield per acre was 51.53 bushels from general selections, 52.22 bushels from 12-row parents, and 46.91 bushels from 14-row parents, which shows that the normal 10-row ears produced the highest yields. This test was begun on April 1, and the crop was harvested on July 14, only 105 days being required for the corn to mature. The following table gives the results of selection on number of rows of kernels to ear.

Effect of selection on number of rows of kernels to ear.

Class.	General selection.			10-row selection.			12-row selection.			14-row selection.		
	Number of ears harvested.	Per cent.	Weight of ears.	Number of ears harvested.	Per cent.	Weight of ears.	Number of ears harvested.	Per cent.	Weight of ears.	Number of ears harvested.	Per cent.	Weight of ears.
			Pounds.			*Pounds.*			*Pounds.*			*Pounds.*
8 rows.....	151	14.35	47.00	125	12.58	32.0	145	15.47	41.5	18	7.66	5.0
10 rows.....	798	75.85	288.00	642	64.65	227.0	675	72.04	220.0	126	53.61	44.0
12 rows.....	89	8.46	42.00	202	20.34	91.0	113	12.06	45.0	74	31.48	32.0
14 rows.....	14	1.33	7.25	24	2.42	11.5	4	.42	2.0	17	7.24	8.5
Total....	1,052	99.99	384.20	993	99.99	361.5	937	99.99	308.5	235	99.99	89.5

Tenth-generation breeding work.—During the year results were obtained from the 10th generation of the ear-to-row breeding work with Guam corn. On June 17, 1919, the corn was planted in 68 rows, and on September 29, 1919, it was harvested, making an average yield of 22.03 bushels of corn to the acre. The highest yield was obtained from rows Nos. 3 and 11, which yielded at the rate of 54.84 bushels of corn to the acre. Rows Nos. 4 and 43 yielded 4.77 bushels to the acre. These were the lowest yields obtained in the test. From all the rows 2,228 ears were harvested, of which nearly 6 per cent were considered suitable for seed purposes and were saved for general field work.

To determine the progress that had been made in this experiment, and to serve as a guide for future work, measurements were taken on the height of the ears from the ground, height of the stalks, and number of nodes above and below the ear, as well as number of ears from a row, weight of corn from a row, and number of selected seed ears from a row. Data showing results obtained with Guam corn in a great many fields located throughout the island were compared

with results obtained in the breeding plats. Average field measurements of 2,112 stalks made without any special selection and 850 measurements made in the 10th-generation breeding plats, along with the average weight of 1,378 field-run ears and 663 10th-generation ears, are given in the following table:

Comparison of Guam-grown corn selected through 10 generations with unselected corn.

Source.	Height of ears from ground.	Height of stalks.	Number of nodes below ear.	Number of nodes above ear.	Weight of ears.
	Feet.	*Feet.*			*Pounds.*
Check	3.83	7.58	7.4	4.77	0.50
10th generation	2.46	6.02	6.5	5.09	.33

After selecting the corn through 10 generations for early maturity, uniformity of type, and for one ear to a stalk, it was found that the height of the ear from the ground has been reduced from 3.83 to 2.46 feet, or 35.7 per cent lower than the average shown by the check plats. The height of the stalks was found to be 1.56 feet lower, which was a reduction of 20.6 per cent. The total number of nodes in the stalks was shown to have been reduced 0.48 of one node. The average number of nodes below the ear was reduced from 7.4 to 6.6 nodes and the average number above the ear increased from 4.77 to 5.09 nodes, or approximately two-thirds of 1 per cent, showing that the decrease in height of ear from ground may not be due so much to a decrease in the length of internodes or a less number of nodes as it is to change of position of the ears upon the stalks.

The most striking difference in the check fields from the tenth generation, and one that might be expected from highly inbred corn, was in the weights of the ears. All were well dried at the time of weighing. Ears from the checks weighed an average of 0.5 pound, while the tenth-generation corn made an average of only 0.33 pound, or was only 60 per cent as heavy as the ears from the check plats. The size of the ear had materially decreased, as well as the size of the cob. The stalks and ears were very uniform throughout the test. The early maturity, uniformity, and single ear-to-stalk characters seemed to have become fairly well fixed during 10 generations of selection. Excessive rains at harvest time and afterward made it very difficult to dry the seed corn properly.

Eleventh-generation breeding work.—Since the desired characters had become fairly well established through 10 generations, it was planned to begin selection work with the eleventh generation for high-yielding strains of Guam corn. However, when seed was selected from the 12 highest yielding rows of tenth-generation corn and

planted in 74 rows it failed to germinate. Six successive plantings were made for carrying on the ear-to-row breeding work, but no seed germinated. A few plantings were then made in the plant house in the hope that some plants would be obtained for future work, but the kernels did not grow. The only explanation which can be offered for these failures is that the seed did not dry thoroughly after it was harvested. This frequently happens in moist tropical climates, although the seed is apparently sound and viable.

Insect pests.—The large number of insects attacking corn in Guam is responsible for heavy aggregate losses each year, and there is a general awakening among the farmers to the need of some practical control measures. The leaf folder and the European stalk borers are probably the most destructive pests. Aphids and leaf hoppers are frequently found and also do much damage.

The leaf folder (*Marasmia trapezalis*) is destructive in the larval stage. It feeds upon the young corn leaves and seems to be present throughout the year. While still very young it folds the outer edges of the leaf together and feeds within the protection thus afforded, eating the upper surface of the leaf. The plant continues to grow for some time after its leaves are folded together, but it becomes very much distorted, loses its green color, and either makes an inferior stalk or dies.

The European corn borer is present in rather large numbers on the island and is most noticeable on mature corn. Damage is very apparent after the corn has begun to tassel. The first sign of the presence of the borers is the breaking over and dying of the tassel, which still hangs to the stalk. This is caused by the tunneling of the insect inside the stalk, which weakens and breaks over. Another indication is the protrusion of frass, a sawdust-like material, from holes in the sides of the stalks. The insect, in addition to attacking corn, has been found attacking grain sorghums, rice, and other plants. Scarcely a plant in the field escaped its ravages, and in some cases the entire inside of the stalk was almost eaten out. One hundred larvæ were found in one stalk of kafir.

A corn borer was first found doing considerable damage in the latter part of 1917, and early in 1918 it was identified by the Bureau of Entomology, United States Department of Agriculture, as the European corn borer. That it was not a new introduction was shown by its wide spread over the island. It was estimated that fully 50 per cent of the corn crop between the Ylig River and Piti was damaged by the pest in September, 1919. However, the crop which followed during the dry season did not seem to be damaged as much as the crop grown in the rainy season, nor did the insects appear to be present in such large numbers.

The full-grown larva is about an inch long and one-eighth inch thick. Its head is dark brown or black. The body on the underside is whitish or flesh colored, and the back is covered with small dark spots or tubercles. The moth, which is brownish yellow, is seldom seen, as it is a night-flying species. It is not known how or when this pest was introduced into Guam. Fullaway [1] mentioned the presence of a moth borer, the sordid white caterpillar of which attacks corn after the stems have formed. This caterpillar is also commonly found in the ears of corn. He determined it as the larva of a pyralid moth which was described from the Philippines by Schultze as *Pyrausta vastatrix*. The description seems to indicate that these two insects are the same species.

No entirely effective remedies or control measures have been found for this insect. The burning of all stalks and cobs as soon as they are dry has been recommended as a preventive measure.

Corn in nearly all stages of growth is attacked by aphids or plant lice (*Aphis maidis*). At times the plants are badly damaged, but usually the harm done is less expensive than control measures would be.

Leaf hoppers are commonly found on the young corn, and to a less noticeable extent on the older corn. The Guam corn is said to be more resistant to these attacks than other varieties.

Beneficial insects.—The ladybug is probably the most beneficial insect to the corn crop observed at the experiment station. The red ladybug with black spots was introduced from Hawaii by this station some years ago. After a large number were bred by the station they were turned loose upon the grounds, and, until recently, only very few were seen afterwards. During the last two years they have frequently been found on the station crops. However, none has been found at any great distance from the station, as, for example, at the east end of the island. In nearly all cases the ladybug was found upon plants infested with aphids or mealy bugs.

RICE (ORYZA SATIVA).

The rice project included studies in variety tests, fertilizer tests, time of planting, and insect-control studies. In general, the rice crop was good, being one of the best in many years (Pl. VI, fig. 1). The injurious effects of the rice bug (*Leptocorisa varicornis*) was lessened by early planting and in some cases by clean cultivation in the field surrounding the paddies. These preventive measures were advised by the station, and where they were carried out the yields were much greater than in fields not so managed.

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[1] Guam Sta. Rpt. 1911, p. 28.

FIG. 1. CORN PLANTING EXPERIMENT. TWO STALKS PER HILL. YIELD, 8 BUSHELS PER ACRE.

FIG. 2. CORN PLANTING EXPERIMENT. SIX STALKS PER HILL. YIELD, 31 BUSHELS PER ACRE.

FIG. 1.—NATIVE METHOD OF THRASHING RICE.

FIG. 2.—COPRA DRYING RACKS AND SHED.

Variety tests.—In 1920 only three varieties of rice were grown at the station for comparative purposes. These were the native Guam rice, the Iloilo variety (a Philippine rice received from the College of Agriculture, Philippine Islands), and a selection made by this station for early maturity to escape the ravages of the rice bug. The native rice matured unevenly in most cases and had to be harvested two or more times. Iloilo rice, which was tried on this island for the first time, matured evenly and was the earliest and highest yielding of the three varieties. The red color of the grain is objectionable to the natives, who prefer a white grain. The station selection matured very evenly but gave the lowest yields. The Iloilo variety was considerably taller than either of the other varieties, while the selected variety was taller than the native rice. The native rice lodged more than did either of the other varieties, although there was only little wind during the rice season. Station plantings of Iloilo matured in 159 days from planting, the selected variety in 173 days, and the native variety in 192 days. In the demonstration fields the native rice matured in 177, 165, and 174 days, respectively, while one field of the selected variety matured in 143 days from planting. The yields of the varieties were as follows: Iloilo, 1,190 pounds; native, 690 pounds; and selected 544 pounds of well-cleaned paddy, or rough rice, per acre. Yields of straw were 6.94 tons, 3.80 tons, and 4.13 tons per acre, respectively.

Fertilizer tests.—During the year interesting results were obtained in the fertilizer experiments with rice, the first series of which was begun by the station five years ago. The comparative results this year were the most satisfactory of any of the tests, because conditions were favorable for rice growing. Plenty of water was available for irrigation, and there were no heavy winds and only few insect pests in large numbers. The plats were planted to the early maturing selected strains of rice, and the yields were not very high as a result, although they were comparable. In general, beneficial results were obtained from applications of nitrogen and acid phosphate in combination. Results obtained during the year confirmed former data regarding the form of nitrogen to apply, and seemingly indicate that sodium nitrate is more beneficial when applied singly than in combination, but that ammonium sulphate gives much larger returns when the nitrogen is applied in combination with other fertilizers. The plats receiving ammonium sulphate and acid phosphate matured from three to six days earlier than the other plats. Potassium was not available this year, and the plat receiving applications the two years previously therefore showed only residual effects of potash. The following table gives the results of the rice-fertilizer test conducted during the year.

Effect of fertilizers on yield of rice planted Sept. 3, transplanted Oct. 23, 1919, harvested Feb. 20–26, 1920.

No. of plat.	Treatment per acre.	Yield per plat.				Average yield per acre.		
		Cleaned paddy.		Straw.				
		Original.	Duplicate.	Original.	Duplicate.	Paddy.	Straw.	Total.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
1	Check	21.0	14.0	295	257	350	5,170	5,520
2	Sodium nitrate, 266 pounds	27.0	24.5	334	387	515	6,695	7,210
3	Ammonium sulphate, 200 pounds	16.0	27.0	286	492	430	7,350	7,780
4	Acid phosphate, 166.5 pounds	23.0	28.0	335	420	510	7,040	7,550
5	Potassium sulphate, 95 pounds	17.0	22.0	228	345	390	5,340	5,730
6	Sodium nitrate, 266 pounds, or ammonium sulphate, 200 pounds; acid phosphate, 166.5 pounds; potassium sulphate, 95 pounds	24.0	22.0	656	654	460	12,640	13,100
7	Ammonium sulphate, 200 pounds; acid phosphate, 166.5 pounds; potassium sulphate, 95 pounds	31.0	35.0	355	332	660	6,210	6,870
8	Ammonium sulphate, 200 pounds; potassium sulphate, 95 pounds	9.0	26.0	156	413	350	5,340	5,690
9	Acid phosphate, 166.5 pounds; potassium sulphate, 95 pounds	25.0	17.5	573	640	425	11,705	12,130
10	Ammonium sulphate, 200 pounds; acid phosphate, 166.5 pounds	26.5	44.0	399	557	705	8,855	9,560
11	Lime, 1,000 pounds	23.0	16.0	366	570	390	8,970	9,360
12	Ammonium sulphate, 200 pounds; acid phosphate, 166.5 pounds; potassium sulphate, 95 pounds; lime, 1,000 pounds	32.5	32.5	662	719	650	13,160	13,810

Plat No. 10, to which nitrogen in the form of ammonium sulphate and acid phosphate had been applied, gave the largest yield of clean paddy (unhulled rice). Plat No. 7, to which a complete fertilizer (nitrogen in the form of ammonium sulphate) had been applied, was next, closely followed by plat No. 12, which was treated similarly to plat No. 7, but received in addition an application of lime. The lowest yielding plats were No. 1, which received no treatment (check), and No. 8, which was treated with ammonium sulphate but received no potash since the previous year. Plats Nos. 2 and 6 were compared with plats Nos. 3 and 7 to determine the better form of nitrogen for rice, the former two being treated with sodium nitrate singly and in combination with other fertilizers, while the latter two were treated with ammonium sulphate in the same manner. In the single treatment, plat No. 2, which was treated with sodium nitrate, gave a yield of 515 pounds of clean paddy; and plat No. 3, which was treated with ammonium sulphate, gave a yield of only 430 pounds per acre. In the plats receiving a complete fertilizer of nitrogen, acid phosphate, and potash, plat No. 6, to which sodium nitrate was applied, gave a yield of 460 pounds; and plat No. 7, to which ammonium sulphate was applied, gave a yield of 660 pounds to the acre.

Time-of-planting tests.—No definite conclusions were reached in the time-of-planting tests. Insects were injurious to many of the plantings and in other than early September plantings did much damage. All plantings required much longer to mature than did those planted in September. Plantings were made during March, May, July, and September. The last planting was the only one giving even a fair yield. The other plantings all matured in December and were harvested December 13, 1918. In an effort to save the planting that had been made earlier in the year, the tops of the leaves were cut back to within 18 inches of the ground on August 25. This removed the leaves killed by leaf folders, which had caused the rice to make a very distorted growth. New leaves were put out by the plants, but all suffered in a manner similar to the previous ones.

Insect studies.—The life history, habits, and methods of control of rice insects are being studied as time permits. With the exception of the harm done by the leaf folder, little insect damage occurred in the main rice crop. The rice bug again did considerable damage to the late-maturing rice on the island, but most of the station fields matured in time to escape infestation.

In the time-of-planting experiments considerable injury was done by a pyralid which folded the leaves together, thus preventing the growth of the plants and giving them a distorted appearance. The stem borer (probably *Nonagria inferens*) caused a small amount of damage during the year.

It would seem that until better control measures can be found it would be advisable to plant early maturing varieties either during the last of August or the first of September and give adjoining fields clean cultivation.

TOBACCO (NICOTIANA TABACUM).

Only a small quantity of variety work was accomplished with this project during the year. Seed of several varieties of tobacco were secured from the Office of Tobacco and Plant Nutrition Investigations, United States Department of Agriculture. Records were kept on time of planting, time of transplanting, time of blossoming, height of plants, and the like, but the data are only comparable owing to poor soil conditions. Seed was obtained from eight varieties of tobacco and planted near the close of the fiscal year. Small plat work with the different varieties will be continued until conditions are again favorable for extensive investigations.

SUGAR CANE (SACCHARUM OFFICINARUM).

During the year much interest was manifested in the production of sugar cane. This interest no doubt was stimulated by the

greatly increased price of sugar and by reports from near-by Japanese islands to the effect that sugar cane was being planted rather extensively. Farmers have repeatedly requested this station to introduce into Guam some varieties of sugar cane which would be better than those now grown on the island. No importations have been made, however, because of the danger of introducing injurious diseases, none of which is known to exist on the island.

Sugar cane is grown on the island principally for consumption of the raw stalk as a sweet, or "dulce," as it is called in Guam. For this purpose the "tupo" or stalk is commonly sold on the market in lengths of two or three feet. At present at least six varieties of sugar cane grow in Guam. These have been grown here for a long time, but no attention has been given to their improvement, and of late years they have received but little cultivation, owing to the low price paid for imported sugar. Plans are under way to start variety trial plantings in the station fields. It is thought that an acclimatized variety, or varieties, can be found which may be greatly improved by selection and proper cultivation. Sugar cane could be grown on a large part of the lowlands, some of which could easily be provided with irrigation and drainage. A number of farmers have planted small plats to sugar cane during the last two years, and a large red or reddish-purple variety, and a large green variety, when given some cultivation, made good growth, the stalks attaining a height of 20 feet. During the year larger plantations were started, and the canes on these are growing well. In Guam crude methods are used in making sugar and in cultivating the cane. Should sugar continue to bring high prices, sugar cane can be grown at a profit, even with the present crude mills; but if sugar reverts to normal prices. it will be necessary to introduce modern machinery and up-to-date methods of production.

SOILS.

A great deal of preliminary work has been done with soils. The soil fertility studies dealt with methods of maintaining and increasing the productive capacity and organic content of the soils. Tests were continued with commercial fertilizers, local fertilizer products, manures, and green-manure crops. Studies were also made to determine methods of improving the low fertility of certain soils on the station grounds and the effects of particular crops upon the soil. Abnormal soils have been found which differ little in chemical composition but vary greatly in productiveness. Low silica and high iron and alumina content have been found in some of the soils. The soils on the uplands are extremely high in phosphorus, but those on the lowlands are less so.

In cooperation with the Bureau of Soils, United States Department of Agriculture, the station has made a complete analytical index of the mechanical and chemical composition of the soils on the station grounds and several other soil types on the island.

A series of pot and field experiments was conducted during the year, and results have been obtained on four consecutive crops which were treated with imported and local fertilizers, as well as on five seasons' work to determine the adaptability of crops to different soils. In all tests a comparison was made between the old station soils and the newly broken, but nonproductive, soils. The latter have continued to improve in productivity with each season's cultivation. A most striking difference was noted between some of the old and new soils which were similarly treated. In some cases the treatment produced almost opposite effects. For example, in the second crop, coconut-husk ash gave the lowest yields when applied to pots containing old soil. On the new soil, however, it gave next to the highest yields. Similar results were obtained with cowpeas which were turned under as a green manure. On the whole, the old soils during the third crop responded better to compounds containing nitrogen and phosphorus, although the green manures also did well, while the new soils responded better to organic matter. Guano, applied at the rate of 300 pounds per acre, gave the lowest yield this year on both new and old soils. Imported lime gave slightly better results than did local burned lime, when both were applied at the same rate.

In the field experiments it was found that applications of barnyard manure and the turning under of green-manure crops offered the best means of increasing productivity and the organic content of the soils. Cowpeas, pineapples, and grain sorghums seemed better able to maintain themselves than did other crops in the infertile soils across the river from the station buildings. Velvet beans grew fairly well after two crops of cowpeas had been turned under. The soil, which two or three years previously would grow scarcely anything, produced fairly good crops of sweet potatoes, cassava, tobacco, and mungo beans, and better crops of cowpeas and pineapples grew during the year.

In the field tests, nitrogen fertilizers and acid phosphate increased yields, but were not as lasting in their effects as barnyard manure. Results of the soil tests showed, along with other things, that although phosphorus is present in large quantities, it is evidently not in an available form, and many soils were benefited by its application in soluble form.

In a small test with soils for plant-house use in flats it was found that passing steam through the soil for a period sufficient to kill fungi and viable seeds before planting prevented weed growth and the damping-off of young seedlings during rainy weather.

Results in soil-improvement work have not been confined exclusively to the station. Several farmers have been induced to grow cover crops, and there is an increasing demand for seed.

As was stated in last year's report, some effort was made to find caves containing deposits of bat guano to furnish available supplies of fertilizer to the farmers of the island. This work was continued this year with better success. Caves were located in the neighborhood of Dededo, Tarague, Talofofo, and Cotot. Some of them contain fairly good sized deposits of guano which could be very profitably used in the districts where they occur. No doubt other deposits are to be found on the island, but the average Chamorro is rather superstitious about caves, and it is hard to induce him to enter them, much less to disturb the deposits within them. Some start has been made in this direction, however, and it is hoped that others will be encouraged to use this local fertilizer when they see the good results that can be obtained with it.

HORTICULTURE.

Work in the horticultural department continued to deal with the improvement of tropical fruits and vegetables, cultural methods, and the adaptation of imported varieties from the States. Work of a reconstructive nature was uninterrupted during the year. This included repairing damages caused by the typhoon of July 6, 1918, and the replanting of many trees and crops. Toward the close of the year it was observed that a number of trees which had been damaged by the storm were beginning to recover. Coconut trees were beginning to bear, and within the next year they will probably yield full crops again.

The first part of the fiscal year was very wet, and the crops suffered from the excessive rains. On the whole, the garden-vegetable work was satisfactory, and the work progressed in a very systematic manner. Tropical-fruit investigations were not so gratifying, owing to insect-pest invasion and the lack of sufficient labor and stock to carry on the work.

On account of the isolated geographic position of Guam, special emphasis was again given to food-producing activities and diversified crops. The island would be in a precarious condition were it shut off, even for a comparatively short period, from outside sources of supply. The possibility of such an event and the conditions resulting therefrom were clearly demonstrated at times during the recent war.

During the absence of the agronomist-horticulturist for five months, the detailed work and supervision of agronomic and horticultural projects were handled by the assistant horticulturist.

In the course of the year just closed a reinforced concrete seed room and seed laboratory was constructed at one end of the propagat-

ing house. No other improvements were made, and no equipment was purchased during the year.

SOIL STERILIZATION FOR PLANT HOUSE.

Seedlings growing in the plant house for transplanting suffered considerably from damping-off. The plants most commonly affected with this fungus disease include lettuce, eggplant, pepper, tomato, papaya, and tobacco. Plant-house work during the year included studies to determine methods of reducing damping-off. Treatments with copper-sulphate solution and the pouring of boiling water on the soil failed to give satisfactory results. The station devised a simple but cheap and effective means of sterilizing the soil for flats by means of steam. The sterilizer consisted of a tank placed over a concrete fireplace and having on top a tight-fitting frame with a bottom made of poultry wire. An old burlap sack was placed on the wire screen and the soil on top of the sacking. The frame was 6 inches deep and of a size that could easily be handled by two men. The steam from the tank passed through the sacking and the soil. Four or five frames could be placed on top of the first one, depending upon the quantity of soil needed. Old logs or worthless fence posts and discarded flats made very good fuel for the sterilizer. The fire was started in the fireplace early in the morning and allowed to burn all day and night. A slow-burning fire was maintained by placing a log in the fireplace and shutting off the draft. By the next morning the soil was sterilized, cooled, and ready for use.

Experimental work was carried on with the above-mentioned plants in both sterilized and unsterilized soil taken from the same bin. In all the tests the seedlings in the unsterilized soil appeared from one to two days earlier and at the outset made a more rapid growth than did those in the sterilized soil. However, in from two to four weeks many of the plants in the unsterilized soil had died, and the remaining ones were in an unhealthy condition. The plants in the sterilized flats, for the most part, showed a good healthy growth, only a small number of them having succumbed to the damping-off disease. A very noticeable difference also existed in the physical condition of the two soils. The sterilized soil was loose and showed a tendency to dry out very quickly. The unsterilized soil ran together and held moisture much better than did the sterilized soil. No weed seeds germinated in the sterilized soil, but the unsterilized soil seemed to be literally filled with them and they grew as rapidly as did the plants in the flats. Preliminary results in from one to three different tests with several kinds of plants indicate that the sterilizing of the soil with steam, as was done in these tests, will largely control damping-off of plants in plant houses similar to the one at this station.

TROPICAL-FRUIT INVESTIGATIONS.

Investigations with tropical fruits did not make much headway during the year owing to the high cost of labor and the shortage of animals required to carry on the work. The soils at the station are also partly responsible for lack of progress, as they are not suited for nursery and orchard work. The orchard location, comprising about three acres, does not drain well during the rainy season, although it is bounded on three sides by a river and has considerable slope. The soil is reddish-brown heavy clay underlain by an impervious subsoil, which runs together and becomes compacted. This unfavorable condition has been somewhat improved, however, by growing cover and green-manure crops on the land, treating it with barnyard and poultry manure, and giving it better drainage through plowing the soil toward the tree rows.

The nursery.—The area of the nursery was greatly extended during the year. Nearly all of the trees in the nursery were pruned severely, followed by one spraying with Bordeaux mixture and lead arsenate. The trunks of the trees were also painted with a coal-tar solution. As a result they were of a more uniform shape and more vigorous in appearance than formerly. Considerable time was spent in keeping the nursery free from weeds, which grow very fast during the rainy season. All of the citrus seedlings were budded, but only 20 per cent of them grew successfully, owing to the heavy rains which followed budding.

Cooperative work.—The naval government of Guam maintains fruit orchards at both the Libugan and Barrigada farms, the work being carried on more extensively at the former place. For the last few years this station has cooperated in a limited way in the orchard work at these farms. At the Libugan farm citrus trees varying from one to four years in age are apparently very thrifty and vigorous, and some of them have started to fruit. These trees, which are seedlings, are properly cared for at the farm, including pruning and coal tarring.

The avocado orchard at this place, consisting of several hundred trees, some of which are about to fruit, has also been well cared for and cultivated, and the trees are in a healthy condition. Libugan farm seems to be well suited for fruit work. The soil at this place is light and fertile, most of it being a friable clay loam. Water from a near-by river is abundant.

Mangoes.—During the year a new mango orchard was started on the Moritz property. Thirty-nine native, or Carabao, mango trees were set out on August 16, 1919, in favorable locations. The trees were placed 24 feet apart in large holes. At the end of the year all, excepting four which died, were growing well. It is planned to bud or graft them as soon as weather conditions permit.

The old Carabao mango trees, which were badly damaged by the typhoon of 1918, fruited during the year. The yield was low, and the fruit was not as large as usual, but it was exceptionally good in quality. One or two aged trees bore fruit this year for the first time. Smudges were made under these trees at the time of flushing, but it is not known whether the application of smoke induced them to fruit. The smoking of mangoes to cause fruiting is a common practice among the Chamorros. Other experiments of this nature will be carried out during the coming dry season. Some of the Saipan mangoes, which were planted along the bank of the river, fruited, but only a small yield was obtained from them, and most of the fruits dropped off prematurely. The Gordon mango, No. 919, which was planted on April 21, 1913, flowered profusely this year for the first time, but set only a few fruits, which were lost.

During the fairs of July, 1919, and February, 1920, the station exhibited young inarched mangoes and budded citrus plants which attracted considerable attention and gave rise to many questions concerning the means of propagation. Propagating plants by cuttings and other asexual methods is still comparatively new to the people of Guam.

Citrus.—Much time was devoted to pruning and budding citrus seedlings. Californian grapefruits, Eureka lemons, and other imported citrus varieties were successfully budded on native lemon and orange seedlings. Some of these budded citrus plants will be kept for the use of the station, and the rest will be distributed. Citrus trees responded very well to treatment, and the effect of pruning and of coal-tarring the trunks and then spraying with lead arsenate in combination with nicotine sulphate was very apparent. Many of the trees made a vigorous growth and have much more shapely crowns and a healthier appearance than formerly. Cover crops were grown to good advantage in the citrus orchard. The growth of side suckers is being checked to some extent, and the damage caused by mealy bugs, caterpillars, and other injurious insects apparently has diminished. Both commercial fertilizers and chicken manure were applied around each tree with very beneficial results. The citrus trees which were planted on September 3, 1915, have not yet blossomed and are still making only slow growth. The older trees are making better growth than formerly.

Strawberries.—On February 4, 1920, the agronomist of the station introduced about 400 Everbearing strawberry plants for the use of the island government and the experiment station. About 100 plants were set out in the garden on February 21, 1920. Plants were also set out at the island government farm at Libugan and in the governor's garden at Agana. At both of these places the

vines are making splendid growth. At the station garden some of the plants produced fruits which were allowed to ripen to determine their quality. The fruits, though small, were of good quality and will probably compare favorably in this respect with those grown in the States. A good supply of propagating material was obtained from the first planting, and from this three other trials were started.

Aberia gardneri.—A heavy crop of fruits was produced by these plants this year after they had been severely pruned. The new shoots, which bear the fruits, grow very rapidly. There has been some demand for the propagating material of this plant, but only a limited supply was distributed. The fruit makes an excellent jam or jelly and has gained some popularity as a fresh fruit.

Grapes.—During the year the grapevines were heavily pruned and made a good growth as a result. A few bunches of grapes set, but they were of inferior quality. After three years of trial, the present location has been found unsuitable for a vineyard. The soil is well drained, but it is heavy and underlain by a hardpan of rocks mixed with some chalk-like formation. A cover crop of mungo beans seemed to improve the condition of this vineyard to some extent.

Roselle.—Three tests with roselle were completed during the year. In all the field tests a very excellent quality of roselle was produced. Through the efforts of this station the roselle has gained some popularity among the people of Guam, and the demand for seed during the year was greater than could be supplied. In response to requests information was furnished relative to the cultivation and the uses of the various parts of the roselle plant. Although roselle is very resistant to drought, it develops very poorly and produces an inferior quality of fruit during a protracted dry period. The calyces of the fruit make excellent jellies, jams, sauce, and the like, while the stems and leaves when boiled make a very savory, mild drink. The following table gives the results of three tests with roselle:

Dates of planting and harvesting roselle, with the yield.

Number of test.	Date of planting.	Date of first harvest.	Date of last harvest.	Yield per acre.		
				Calyces.	Pods.	Total.
				Pounds.	*Pounds.*	*Pounds.*
1	Jan. 2, 1918	Apr. 3, 1918	Nov. 21, 1918	374.16	772.50	1,146.66
2	Jan. 4, 1919	Mar. 19, 1919	Nov. 27, 1919	575.79	916.31	1,492.10
3	Dec. 26, 1919	Mar. 19, 1920	.....	.....	.....	[1] 434.98

[1] Only one harvest was secured from test No. 3, which accounts for the low yield.

Papaya.—A test with papaya, which was begun September 23, 1918, was completed during the year. Fourth-generation Guam-

grown seed was used in this test. The fruits produced in most of the plats were very small and of inferior quality. This result somewhat corroborates the general local opinion that papayas produced from Guam-grown seed gradually deteriorate in size. It is assumed that this condition is due to change of environment and, to some extent, to pollination from wild native papayas. Only very meager data were obtained from this test owing to the frequency of heavy winds which damaged most of the plants.

Pineapples.—Work with pineapples progressed very satisfactorily during the year, and two crops were gathered in the fertility tests. The smooth Cayenne gave the largest yield of fruits and was more prolific than Thorny Red (probably Red Ceylon) and the native variety. Nearly all of the old plants in the fertility test show a tendency to change their color from a deep green to a yellowish purple. Propagating material of the Cayenne variety was very much in demand, but the station was able to supply only a limited quantity.

Twelve rows of pineapples adjoining the variety and fertility tests were planted on September 8, 1919. The object was to determine for the several varieties the difference in time of fruiting from plantings of suckers and crowns. At the end of the year very noticeable differences were observed between the growth of suckers and the growth of crowns. The suckers of all varieties appeared to be more vigorous than the crowns. The former have a tendency to spread out and produce more propagating material, while the latter have more of an upright nature of growth and do not spread much. Most of the plants that were grown from suckers have already produced fruits, while those grown from crowns showed no indication of flowering. The following table gives the results in yield of two crops of Smooth Cayenne and Thorny or Red Ceylon, varieties of pineapples treated with fertilizers.

Effect of fertilizers on yield of two varieties of pineapples.

Treatment per acre.	Smooth Cayenne variety.				Red, or Thorny, variety.			
	Yield per acre.			Average weight of each pine.	Yield per acre.			Average weight of each pine.
	First crop.	Second crop.	Total.		First crop.	Second crop.	Total.	
	Tons.	*Tons.*	*Tons.*	*Pounds.*	*Tons.*	*Tons.*	*Tons.*	*Pounds.*
Check	2.14	5.72	7.86	5.00	0.23	0.71	0.94	2.15
Sodium nitrate, 400 pounds	4.03	4.38	8.41	3.22	1.32	2.46	3.68	1.60
Ammonium sulphate, 300 pounds.	7.51	2.27	9.78	4.23	.94	2.81	3.75	2.30
Bone meal, 1,500 pounds	9.03	1.79	10.82	4.35	1.67	2.64	4.31	2.04
Acid phosphate, 745 pounds	7.25	1.85	9.10	3.79	.73	3.11	3.84	2.98
Manure, 12,000 pounds	5.90	2.35	8.25	3.53	1.88	1.98	3.86	2.06
Check	3.10	3.73	6.83	3.72	.19	2.01	2.20	2.17

The highest average weight of pineapples was obtained from the first check plat of the Smooth Cayenne variety, but the yield of each of the two check plats was lower than that of any of the treated rows of the two varieties. These results show also that bone meal, followed by ammonium sulphate and acid phosphate, gave an increased yield over the average of the two check plats of 3.47, 2.43, and 1.75 tons, respectively, of Smooth Cayenne, and 2.74, 2.18, and 2.27 tons, respectively, of Red, or Thorny, pineapples.

GARDEN-VEGETABLE DEMONSTRATIONS.

The garden-vegetable work was maintained on the same lines as formerly and with very satisfactory results, much of it being done through a cooperative arrangement with the naval government of Guam. Under this plan the latter furnished the labor and received in return the vegetables, which were then disposed of through the government market. The labor was under the direction of the station, which collected all the experimental data accruing from the work.

Plantings of different vegetables were made every month and more frequently when possible. Data were obtained on regular time-of-planting experiments, cultural methods, improved or better varieties for Guam, and insect and disease studies.

The regular fertilizer experiments with vegetables were suspended at the beginning of the year because of the high cost of commercial fertilizers, especially potash. Owing to the presence of a root-rot disease (apparently caused by nematode injury) during the latter part of the year a part of the garden was planted to general field crops, and the vegetables most susceptible to the disease were planted in the regular field. The disease developed in the tomato plats and later appeared in the eggplant and bean plats.

Diversified gardening is gradually coming into prominence on nearly every farm in Guam. Practically every farm has its own vegetable garden to supply the needs of the family, and the station is encouraged by the attention now given to garden crops. The exhibits of American vegetables at the various district fairs of the year evinced the advancement made in this direction. The spirit of rivalry created by these fairs is an important factor in promoting agriculture in Guam.

Tomatoes.—Work with tomatoes has not been carried on long enough to justify the reaching of any definite conclusion; nevertheless, the results obtained indicate that certain varieties of tomatoes can be profitably grown in Guam, provided they are planted at the

right season of the year. Plantings made about the end of the rainy season or from September to January gave the best results. Tomato work is considered a very important phase of the vegetable project. Of the several varieties of tomatoes tested, two, Cristobal and the Hawaiian hybrid, seem best adapted to Guam conditions. Improvement and selection work will be continued with these two varieties. The distribution of seeds and plants of these two new varieties has resulted in the extension of areas grown to tomatoes. They are now practically the only varieties sold in the central market or exhibited at the fairs. Both varieties are prolific bearers. Smoother fruits are gradually being developed through selection from Cristobal. Staking and pruning the plants to two stems somewhat improved the quality and size of the tomato, though it materially decreased the yield of fruit.

The following table gives the results of 13 tests which were completed during the year:

Results of 13 tests with tomatoes.

No. of test.	Variety.	Date planted.	Date of first harvest.	Date of last harvest.	Number of fruits per acre.	Weight of fruit per acre.
						Pounds.
1	Hawaiian hybrid F_2	May 3, 1919	Aug. 18, 1919		1,033	[1] 140
2	Cristobal F_5	do			[2]	
3	Stone F_1	do			[2]	
4	Ponderosa F_1	July 25, 1919			[2]	
5	Dwarf Champion F_1	do			[2]	
6	Hawaiian hybrid F_3	Sept. 28, 1919	Dec. 8, 1919	Feb. 26, 1920	192,267	19,829.2
7	Hawaiian hybrid F_3	do			[2]	
8	Dwarf Champion F_1	Oct. 10, 1919			[2]	
9	Hawaiian hybrid F_3	Oct. 30, 1919	Jan. 15, 1920	Apr. 2, 1920	102,156	9,019.44
10	Cristobal F_6	do	do	Apr. 12, 1920	89,034	11,391.67
11	Hawaiian hybrid F_4	Jan. 20, 1920	Apr. 22, 1920	May 27, 1920	13,680	1,023.00
12	Cristobal F_6	Feb. 20, 1920	Apr. 10, 1920	May 24, 1920	58,378	5,609.86
13	Cristobal F_7	Mar. 8, 1920	May 24, 1920	July 1, 1920	44,025	4,457.98

[1] Very poor stand. [2] Failure.

Lettuce.—During the year tests were made with the varieties White Paris Cos, Iceberg, and Mignonette. White Paris Cos, although comparatively a heavy yielder, is not as crisp and tender as the other varieties, and at times tends to lose its palatability and become bitter. Iceberg is a small early variety and yields a fairly good quality of lettuce. Mignonette, the smallest and most savory of the three varieties, is of excellent quality, being crisp and tender. No disease was noted in the tests completed.

The following table gives the results obtained with 22 plantings of lettuce during the year:

Results of 22 plantings of lettuce.

No. of test.	Variety.	Date of planting.	Date of first harvest.	Date of last harvest.	Yield per acre.
					Pounds.
1	White Paris Cos	May 15, 1919	June 16, 1919	July 17, 1919	2,962.50
2	Do	Aug. 16, 1919	Sept. 20, 1919	Oct. 25, 1919	5,825.00
3	Do	Sept. 2, 1919	Oct. 3, 1919	Nov. 24, 1919	5,868.75
4	Mignonette	Nov. 1, 1919	Dec. 14, 1919	Dec. 30, 1919	2,387.50
5	White Paris Cos	Nov. 8, 1919	Dec. 10, 1919	Dec. 22, 1919	12,181.25
6	Do	Nov. 11, 1919	Dec. 22, 1919	Jan. 10, 1920	9,200.00
7	Do	.....do.....	.....do.....	Dec. 30, 1919	8,562.50
8	Mignonette	Nov. 28, 1919	Jan. 6, 1920	Jan. 30, 1920	2,400.00
9	Do	Jan. 3, 1920	Mar. 11, 1920	Mar. 19, 1920	2,875.00
10	Iceberg	.....do.....	Feb. 24, 1920	.....	7,175.00
11	Mignonette	Jan. 14, 1920	.....do.....	Feb. 27, 1920	1,012.50
12	Iceberg	.....do.....	Feb. 8, 1920	Feb. 24, 1920	8,437.50
13	Mignonette	Jan. 24, 1920	.....do.....	.....do.....	2,662.50
14	White Paris Cos	Feb. 14, 1920	Mar. 15, 1920	Mar. 16, 1920	5,137.50
15	Mignonette	.....do.....	.....do.....	Mar. 27, 1920	3,012.50
16	Iceberg	Mar. 10, 1920	Apr. 23, 1920	.....	1,912.50
17	Mignonette	.....do.....	Apr. 13, 1920	May 20, 1920	3,462.50
18	White Paris Cos	.....do.....	Apr. 8, 1920	Apr. 23, 1920	2,575.00
19	Iceberg	Mar. 20, 1920	Apr. 23, 1920	Apr. 26, 1920	2,937.50
20	White Paris Cos	.....do.....	Apr. 26, 1920	May 6, 1920	4,056.25
21	Mignonette	.....do.....	Apr. 28, 1920	May 20, 1920	5,912.50
22	Do	Mar. 25, 1920	May 17, 1920	June 2, 1920	7,187.50

SEED AND PLANT DISTRIBUTION.

The distribution of seeds and plants continues to be an important phase of the station's work. In addition to distributing propagating material, the station carried on studies to determine the best methods of selecting, saving, and storing seed, and gave instructions to the farmers as to the proper methods of planting. This work is of especial value in Guam, where agriculture is still in a primitive state, and where every kind of encouragement is necessary to promote it. The rapid deterioration of seeds in the Tropics, and the absence of seed dealers make it all the more necessary to continue this work. The people are gradually being taught how to use the imported seeds, and they are beginning to appreciate the efforts of the station in this branch of the work. The isolated location of Guam strongly emphasizes the importance of producing home-grown foodstuffs rather than depending upon importations. The impetus to grow more foodstuffs at home, both during and after the war on account of abnormal transportation conditions, caused a greater demand for seeds than the station could possibly supply. This lack of seeds was more noticeable when the extension work was started, as a large quantity of seed material was required by the station to start the club work properly. The demand for fruit plants, especially for avocado, grapefruit, Hawaiian pineapples, papaya, Lacatan bananas, and mangoes, was stimulated by the governor's order, which required that a certain number of fruit trees and various farm crops be planted by every able-bodied man over 16 years of age, unless he had some regular work other than farming. Fruit trees and plants are being supplied as rapidly as the station can obtain propagating material.

At the close of the year the station was ready to distribute from its nursery lemon, orange, and tangerine seedlings; a few shade trees; and about 2,000 kapok seedlings. Kapok seed is also ready for distribution. It is thought that this seed will be very much in demand within a short time, owing to an executive order advising the farmers to plant kapok for permanent fence posts. The distribution of vegetable seed was not as large as that of last year, but the total distribution of economic, ornamental, and field-crop seeds, plants, and rooted cuttings exceeded that of the previous year. The call for ornamental plants, especially for hibiscus and Barleria, was greater than in other years. With the exception of the requests for these two ornamentals, most of the demands came from members of the American colony. The distribution of Barleria is general throughout Guam. In many of the towns of the outlying districts, especially at the southern end of the island, a majority of the homes have a well-kept hedge of this shrub. *Barleria cristata* is known to the people of Guam as the "Thompson plant," J. B. Thompson, formerly agent in charge of this station, having introduced it from the Philippines.

During the last five years the station has recorded the distribution to farmers and other interested persons of 28,995 packets of vegetable seed, 98,024 rooted cuttings and seedlings of ornamentals, economic plants, and grass roots, 855 packages (mostly in pound or half-pound containers) of legumes, 7,088 pounds of selected seed corn, 201 heads and packages of sorghum, 9 bushels of cotton seed, 480 pounds of selected rice seed, and small quantities of various other kinds of seeds, in addition to several hundred pounds of leguminous seed that was not put up in special packages.

BANANAS.

Work with bananas for the last two years has been very unsatisfactory owing to adverse soil and weather conditions. The plants have never entirely recovered from the effects of the typhoon of July 6, 1918, and other strong winds in 1919. It is evident that windbreaks are needed for bananas, especially for the Lacatan variety, which was severely damaged by the occasional strong winds of the year. Most of the Lacatan bananas fruited during the year and were still yielding at the end of the year. Records of the yields will be reported at the completion of the experiment. The people are beginning to appreciate the flavor and greatly increased yields of the many better varieties of bananas which are now becoming more common on the island. The Lacatan variety has rapidly come into favor, and the demand for the suckers of this variety was so much greater than the station could supply that the banana plants were

allowed to produce more than the usual number. This variety was imported into Guam by the island government in 1917. Since that time it has been spread throughout the island by the station and the island government farm at Barrigada, both of which have distributed generous numbers of suckers.

A few varieties of bananas, as, for example, Guaju and Macao, which have been growing in Guam for many years, compare favorably in quality with the Lacatan variety, but their distribution on the island is limited because of their slow production of suckers. The Lacatan promises to become the best variety for Guam. It yields good-sized bunches of fruit of fine quality. It is said that the variety known as the Manila banana is produced in less time than the Lacatan, and makes a larger yield, even though its bunches are small.

The variety experiment with bananas at the station was discontinued about the middle of the year because of the poor location of the area. Every year two or three freshets would sweep over the entire area and wash off a great deal of the surface soil. This flooding damaged the plants severely, and it was therefore deemed advisable to remove the bananas and plant in their stead Para grass for pasture.

The cooperative experiments at the island government farms were discontinued, owing in part to shortage of island funds. No definite results, other than those with cover crops, soils, and the adaptability of the area to banana growing, were obtained from these experiments. The banana plantation at the Barrigada farm was exposed to occasional strong winds which did much damage to the plants. The feeding area of the roots was confined by the compacted nature of the subsoil, and the plants made only a limited growth as a result. The soil in the banana plantation is very thin and is underlain by a layer of impervious clay mixed with a hardpan of cascajo, and practically every hole had to be dynamited before the bananas were planted. The test was therefore discontinued.

Velvet beans of the Black Mauritius variety were grown to good advantage as cover crops and demonstrated their efficiency in keeping down weeds and in protecting the soil from washing.

CACAO.

Work on cacao has never been definitely started. Of the 20 small trees which were reported to be growing at the station in 1917, only a few were living at the close of the present fiscal year. These did not seem to be making any more progress than when they were first planted. A good supply of cacao seedlings is now growing in the slat house. These plants have been started and potted in bamboo pots and are ready to be set out.

On June 4, 1920, 45 cacao seedlings were set out on the Moritz property, which adjoins the banana plantation at the south side. Good-sized holes were made for the plants, and in each hole one shovelful of well-rotted manure was placed. The plants were set out 12 feet apart in each direction. This test was made on a well-drained area which was moderately well protected from winds by banana plants growing on the outer edges of the field. Seeds for these plants were obtained from the Yigo district about the end of January, 1920. The plants are making fairly good growth. It is planned that, as soon as funds are available for more labor, this experiment will be carried on as a regular fertility test.

The Yigo district formerly was noted for growing cacao, and prior to the occurrence of a very disastrous typhoon in 1900 it supplied practically all the cacao for the island. The decline in this industry is probably due to the prevalence of certain diseases and to importations in later years of the manufactured cacao-bean products. However, it is said that the quality of cacao grown in Guam is far superior to that of any imported brand, and it is hoped that through the efforts of this station the industry can be revived.

COFFEE.

The shading and fertilizing experiments with Arabian coffee which were begun in November, 1917, were failures. The few seedlings that are now growing hold very little promise of improvement. Repeated unsuccessful attempts to grow coffee on this particular area have made it apparent that the location is not adapted to coffee growing. These failures are probably due to the low altitude and to the proximity of the area to the seashore. Liberian coffee seedlings are growing in the slat houses and will be tried in the field as soon as conditions permit. These seedlings were obtained from a farmer at Yigo, who has quite a plantation of both the Liberian and the Arabian coffee.

COCONUTS (COCOS NUCIFERA).

Work with coconuts has not as yet received the attention at the station that would seem to be justified by the importance of the industry to the island. It is only recently, however, that local planters and officials have shown any considerable interest in improved planting and cultural methods, means of securing better nuts, and the making of a high grade of copra. Farmers are taking a new interest in plantings and there is an increasing demand for information regarding the best methods of handling coconuts and plantations to gain larger returns. The naval government of Guam recently promulgated laws regulating the grade of copra exported

from the island. Under these regulations Mr. Nelson of the station staff has been appointed copra inspector and examiner of all export copra presented. While a high standard can not be established at once, a gradual improvement can be effected by educating the people to adopt improved methods. In the hope of bringing this about, the experiment station has been active in encouraging and advising the people regarding the proper methods of drying copra, and constructing and using drying sheds (Pl. VI, fig. 2). Instructions have also been given on the care of trees and nuts, and especially on the gathering and storing of nuts during the rainy season and until the weather is suitable for making good copra. Some improvements are already noticeable as a result of this work. A number of planters have provided themselves with drying racks and sheds, and many of the lots of copra brought in to market show a marked improvement in quality.

During the last year there was established on the island an oil mill which is now extracting oil and making coconut meal and several grades of soap. The addition of this industry should greatly benefit the farmers of Guam. The meal can be fed to live stock, thus saving the importation of large quantities of concentrates. The fertilizing elements in the waste coconut products can be used by the farmers on the island and need not be lost, as is the case when copra is sent to other countries.

Plans for importing a cargo of well-selected seed nuts from Zamboanga, Philippine Islands, did not materialize owing to lack of transportation facilities at the time. Later on it was impossible to obtain the seed because of a serious typhoon which destroyed many of the nuts at the above-mentioned place.

An attempt is being made to gather from other countries some data for comparison of methods of growing, harvesting, improving, and marketing coconuts in the hope of getting reliable information as to methods and practices which will be applicable to Guam.

Cover crops.—As was reported last year, the cooperative work with coconuts at Tarague on the Atkins-Kroll plantation was to be greatly extended, both in area and in activities. During the year one plat was dynamited and the area in cover crops was greatly extended, but the continuous tillage test was not carried on as regularly as it had been planned on account of the absence for several months of the manager of the above company. However, it is intended to carry out the work as planned in the near future.

The most noticeable progress in the coconut work during the year was that of extending the area under cover crops at Tarague. In addition to the regular acre test plats 25 acres were planted to Patani beans. The vines made a quick, dense growth and were keeping the weeds and underbrush down to such an extent that the foreman was

anxious to obtain more seed and plant larger areas. At the end of the year while slashing was being continued 40 more acres were cleared among the trees and prepared for planting to cover crops.

This cooperative demonstration has been very successful. At first the planters were skeptical about planting cover crops, as their aim had been to try to prevent all vegetative growth among the coconuts. One-acre plats were first allotted for each variety of beans, but since they have so successfully kept down weeds and brush and wild papaya, the owners are enthusiastic about extending the use of cover crops to the whole plantation. The Japanese foreman believes that after the cover crops are once established he and five other men can take care of the whole plantation, which formerly required 30 or more laborers to keep in good condition.

In the tests carried on during the year the Patani beans made a more efficient cover crop than did the cowpeas, velvet beans, or jack beans. Velvet beans did well when once well started, and the late-maturing varieties did better than the earlier ones.

Fertilizer tests.—Fertilizer tests were conducted only with young trees that had not begun to bear. In the plat treated with ammonium sulphate at Tarague, the leaves of the trees had a much darker green color and a more healthful appearance than had those of any other plat, but no other beneficial results were noted.

In the fertilizer tests at Cotot, the general notes regarding the growth of the palms were taken in May, 1920. The coconuts were transplanted in February, 1917, and are small for the length of time they have been growing. The first nine plats were treated culturally alike, the only difference being in the application of fertilizers. The following table gives the results of the test.

Effect of fertilizers and grass upon the growth of young coconuts.

No. of plat.	Treatment per tree.	Average height of trees.	Average circumference of trees.	Average number of leaves per tree.	Remarks.
		Feet.	*Inches.*		
1	Ammonium sulphate, 2 pounds	9.11	27.5	7.33	Dark green, but small.
2	Ammonium sulphate, 1 pound; acid phosphate, 2 pounds.	10.75	30.8	8.30	Dark green; growing vigorously.
3	Ammonium sulphate, 1 pound; acid phosphate, 2 pounds; potassium sulphate, 1 pound.[1]	8.94	27.1	8.00	Uneven size; yellowish.
4	Acid phosphate, 2 pounds	8.55	26.3	8.70	Medium size; yellow.
5	Potassium sulphate, 2 pounds [1]	9.35	25.9	8.60	Do.
6	Lime (air-slaked), 4 pounds	9.70	27.4	9.50	Small and yellow.
7	Ammonium sulphate, 1 pound; potassium sulphate, 1 pound.[1]	10.80	28.8	10.30	Dark green; uneven size.
8	Potassium sulphate, 1 pound;[1] acid phosphate, 1.5 pounds.	10.50	28.6	9.55	Large and dark green.
9	Check (untreated)	8.78	24.0	10.20	Small; slightly yellow.
10	Check (grass removed)	12.83	38.0	11.11	Dark green; much larger than others.

[1] Potassium sulphate not applied this year.

All the trees on fertilized plats were larger than those growing on check plat No. 9. On the whole, it will be noted that the largest coconut trees were those receiving ammonium sulphate and acid phosphate. The measurements of the circumference of the trees were taken 1 foot above ground.

Cultural experiments.—An experiment to show the effect of Para grass on growth of young coconut trees has been under way for the last three years. In the foregoing table the results are apparent in a comparison of plats Nos. 9 and 10, neither of which received an application of fertilizer. Unfortunately, Para grass was planted in all the plats, and twice each year it was removed from around the trees in the first nine plats, while in plat No. 10 it was removed from the whole. The results show that the trees are much larger where the grass is not allowed to make a permanent growth. The effect of the grass upon the growth of the trees did not seem to be overcome by the application of fertilizers, as the trees in the untreated plat, whence the grass was removed, were larger than any of those growing on the fertilized plats.

In July, 1919, an experiment was begun to determine the effect of dynamiting soil underlain by hard cascajo rock, upon which coconut trees two years old were growing. The dynamited plat was 1 acre in extent and contained 48 trees. The soil in the plat is of a red, loose nature and is from 6 to 12 inches deep. Considerable labor was required to drill the holes, which were 3 feet deep. These holes were placed half way between the rows in each direction, and one was centered in a square formed by four trees. A charge was therefore placed about every 12 or 15 feet.

The dynamiting was a modified system of pot-holing. Four sticks (1 pound) of 40 per cent strength dynamite were used in each hole. Before being placed in the holes three sticks were broken or crumbled; the fourth stick, which contained the detonator, was placed on top of the others. All the sticks were well tamped. This caused the charge to scatter the cascajo for a considerable distance and depth and to blast out only a small hole at the surface of the soil. At the end of the year the soil was still in a loosened condition, but very little difference could be seen between the trees growing on this plat and those on the surrounding plats. On soil of this character it doubtless would be better to dynamite the soil before planting the trees and then place the coconut trees in the area shattered by the charge of dynamite.

Young trees in which intertilled crops, corn for example, were planted between the rows apparently were in better condition and made a more rapid growth than did uncultivated trees or trees planted in wooded areas.

In the older coconut areas at Taragüe a herd of cattle is being pastured on the native grass (*Stenotaphrum subulatum*, locally called Las-ága) growing among the trees. As a result, no injury is apparent in the trees or in the production of this area. The pastured area was also freer from brush than were the other areas, but this perhaps was due to some extent to the denser shade furnished by the larger trees.

Disease and insect-pest investigations.—During the year a number of inquiries regarding coconut pests and diseases were received at the station. Reports of disease received prompt attention, and whenever it was possible to do so the localities were visited, investigations were made, and the trees inspected. In no case were dangerous pests present in numbers large enough to do much damage, and in nearly all cases the injury was limited to a single tree, or at most, to a few trees. The station advised the burning of all trees which were in an extremely unthrifty or unhealthy condition, whether due to pests or to physiological or other conditions that could not be determined. This precluded the possibility of any dangerous pest or fungus spreading to other trees. The only disease which was present was leaf spot (*Pestalozzia palmarum*), which was not serious.

A borer (probably the common sugar-cane borer *Rhabdocnemis obscurus*) was found in the north and east sides of the island, where it has evidently been for some time. This pest bores holes at the base of the leaves, the harm done not being perceptible until after the leaves fall. The holes resemble those made by a .22 caliber bullet.

A large green walking-stick is thought to be responsible for damage to coconut leaves, many of which were eaten around the edges. In some instances the leaflets were so severely damaged that only the midrib remained. On the whole, however, the damage was negligible, and the writer could not find this insect present in sufficient numbers to account for the extensive damage occurring in short periods in some of the coconut groves. The leaves sometimes become torn and shredded from whipping and other mechanical means.

Several reports have reached the station of the presence in Guam of what is locally called the "Saipan disease." As was mentioned in the 1917 and 1918 reports, a serious coconut pest was doing considerable damage in Saipan, the next largest island of the Marianas group. Upon investigation by this station a scale insect (*Aspidiotus destructor*) was found not only ravaging the coconut trees, but also attacking the fruit and foliage of bananas, papayas, and breadfruit trees of that island. All reports concerning its local presence were carefully investigated, but in no instance was the insect found. Since 1917 this station has taken every precaution to prevent the introduction into Guam of coconut pests or diseases through importations.

Henry E. Crampton, of the American Museum of Natural History, New York, who was in Guam doing research work, visited the island of Saipan toward the close of the fiscal year and at the request of the station made inquiries concerning the coconut situation there. Dr. Crampton furnished the station with the following memorandum relating to these inquiries:

> The scale was destructive about 1912 and reached really great proportions by 1916. The prevalent opinion is that the scale reached Saipan from Yap. About 70 per cent of the trees were killed. The present condition is better than before. It is true that the general appearance is one of devastation, but the topmost clusters of leaves on many trees are fresh and green. Of course, the production of copra has greatly declined. On the whole, the pest seems to be declining in severity, Mr. Kowno believes, though exactly what counter-parasite measures are employed I could not ascertain definitely.

Copra.—The coconut is the largest and the chief money crop of Guam and furnishes the only export of great value. Formerly the product of the coconut palm supplied practically every want of the Chamorros. It gave them food, drink, shelter, building material, utensils, brooms, fiber, and other things of economic value. Indirectly it is still doing the same, but in a different manner. With the progress of education and civilization the people are adopting a higher and more expensive standard of living. To balance this increased expense it has been necessary to secure a greater production from the soil, because there are no other resources on the island. This the coconut is doing by supplying copra, the dried meat of the nut, from which is expressed the coconut oil of commerce. The following table shows that the copra industry has increased in Guam:

Amount of copra exported from Guam since 1900,[1] and the price paid for it.

Year.	Copra shipped.	Price paid for shipments.	Year.	Copra shipped.	Price paid for shipments.
	Pounds.			*Pounds.*	
1900	1,027,947	$19,200.68	1915	1,238,538	$38,718.64
1909	1,094,987	50,751.30	1916	1,941,568	61,278.72
1910	1,069,415	33,610.11	1917	2,234,050	67,315.44
1911	1,741,000	51,058.80	1918	2,404,899	105,176.79
1912	2,094,000	59,924.10	1919	1,992,604	73,979.82
1913	985,445	35,707.89	1920	454,073	24,731.47
1914	1,360,051	49,830.69			

[1] Custom records covering exports for the annual periods ending June 30 for twelve years and for the calendar year 1900.

The falling off in production during 1913 and 1919 was due to destructive typhoons. Of the amount given for the latter year, fully three-fourths was produced during the preceding year, but it was not exported because of the lack of transportation. The results of the 1918 typhoon are still apparent in the exports for the fiscal year 1920, although a certain amount of copra was used this year by the newly established local mill previously referred to. These

figures by no means indicate the actual number of coconuts raised on the island, as it is estimated that fully as many again, if not more, were used locally as food for human beings and as feed for live stock.

In Guam coconuts are gathered to some extent at all times of the year, but the bulk of the copra is made only during suitable weather periods. The small grower markets considerable copra which is insufficiently dried or was made during unfavorable weather conditions. It is hoped that under the regulations recently made this situation will be remedied. During some years when there is no definite dry season, copra must of necessity be made under conditions unsuitable for the best drying. Artificial heat has never been used to any great extent for drying copra in Guam, but the planters dry the meat upon mats placed in the sun. The coconut is not used as a food in the dried state on this island, and it should be properly prepared for export trade which requires great quantities for expressing the oil for food use and for making soaps and glycerine. Guam copra has been of a very poor grade in the past and was largely used for making soap.

The practice of the Guam farmer has been to sell copra in an improperly dried state so that he could realize on the water remaining in the nuts. When copra is green or poorly dried, fermentation sets up in the tissues, and a fungus, commonly called mold, begins to grow. This, in turn, starts oxidation, which forms free fatty acids and causes the copra to throw off a rancid, disagreeable odor. By the time this copra has reached a foreign market it has deteriorated considerably, and, as a consequence, it brings a very poor price. Even a small quantity of poor copra mixed with good copra will cause rapid deterioration in the whole cargo. In the past no more was paid for good copra than was offered for copra of poor quality. This was due to placing all copra, regardless of quality, in the same cargo and selling the shipment at the price paid for the lowest quality in the cargo. Under the new law only copra of good merchantable quality can be exported.

The present improved quality is shown by comparing copra formerly shipped to San Francisco with that shipped since the enactment of the new regulations. It is true that when first made the inferior, poorly dried copra weighs more than does the first-class product. This difference in weight, however, is more than offset by the difference in price paid for the better product, because the loss in shrinkage and deterioration while in storage and transit is much less in the latter than in the poorly made or green article.

In view of the large number of observations that have been made by this station, partial summaries of which were reported last year, the following conclusions have been reached regarding the making and preparation of copra in Guam:

(1) Only fully matured and well-cured nuts that have fallen to the ground of their own accord should be used for making copra.

(2) Nuts should be gathered at regular intervals and placed in a dry place off the ground so that they will not sprout.

(3) Nuts cared for in this manner for two or more weeks will absorb all, or nearly all, of the water in the cavity of the coconut and become "cured." Mature nuts will keep several months.

(4) Copra should be made on a clear day, at a time of the year when there is little rain.

(5) Copra should be kept clean.

(6) Copra should be dried on frames which are raised from the ground at least 2 feet. This will give a better quality of copra than if dried on mats, on account of the better circulation of air.

(7) Drying frames that can be easily handled have been found to be the most convenient.

(8) Drying sheds or other means of protecting the copra from rain should be provided. The station constructed a shed which was so arranged that the drying frames could be pushed under shelter at the approach of rain, or for the night. The material used to make the shed and frames was procured locally and consisted largely of bamboo poles and coconut leaves.

(9) Copra dried during five days of sunshine keeps better than copra dried for three days only.

(10) Copra should not be placed in bags, mats, boxes, or piles for any length of time before it is dry.

Good copra should be almost pure white and have a sweet taste. It should be brittle, show a clean fracture when broken, and have no odor, and should contain not more than 5 or 6 per cent of water. Moreover, it should be such that it will make a clear oil having a pleasant odor.

This station has devised a tentative copra score card to be used by members of the boys' and girls' club in judging contests at the Guam Industrial Fair, as well as in scoring samples at the district fairs and in grading the copra of the island. The following score card gives the scale of points used in judging copra:

Score card for copra.

Requisites for good copra.	Possible score.
	Per cent.
Dryness: (Should be well dried)	20
Cleanliness: (Should be free from dirt, sand, mold, etc.)	15
Texture: (Should be brittle so that it will break with a snap)	15
Color: (Should be white and not discolored)	15
Freedom from rancidity: (Should not have an unpleasant odor)	15
Oil content: (If well dried, clean, of good texture and free from rancidity, the oil content will be high)	20

REPORT OF THE SUPERINTENDENT OF EXTENSION.

By W. J. Green.

Extension work was continued along three general lines: Adult demonstrations, school gardens, and boys' and girls' club work, as outlined in the report for last year. The boys' and girls' club work is the most popular of the three projects and seems to be doing the most good. However, much interest has also been manifested in the other two projects, and the work as a whole has become fairly well established and has made satisfactory progress during the year. Pleasant cooperative relations have been maintained with the various departments of the island government and with the Department of Education.

Extension work in Guam presents many problems not encountered in other countries. With the exception of a few large coconut plantations, the farms or ranches, as they are locally called, are very small, the cultivated area consisting of only a very few acres. The people for the most part live in the towns and villages and go out to the farms to work. Many of them have other employment and handle their ranches as a side line only.

With the exception of a few leading men in each community very few of the older people speak English. Chamorro is the universal language, even with the children, although they are required to use English in the schools. For this reason the superintendent found it necessary to acquire a sufficient knowledge of the native language to make himself understood in the absence of an interpreter.

The great problem of all agricultural work in Guam is to make the island self-supporting. Since the American occupation it has never produced enough food for its own needs. All the extension work is conducted with a view of helping the farmer to depend less upon importation for his foodstuffs.

ADULT DEMONSTRATION WORK.

It has been found that adult demonstration work in Guam is much more difficult to establish and continue than in the States. The average Chamorro farmer is very slow to adopt new methods. He is apparently enthusiastic about a certain thing when some one is talking to him, but forgets all about the matter as soon as the person leaves. For this reason the work requires very close personal supervision. In every community there are certain progressive farmers who are regarded as leaders. The cooperation of such men has been enlisted in some form of demonstration work, because when they become interested, others are apt to follow. This plan was followed with great success in changing the methods of making copra. In

July an executive general order was issued by the governor prohibiting the exportation of any but first-class copra. Methods of copra drying recommended by the experiment station were explained. At first very few seemed willing to use these improved methods. A Japanese merchant was the first man to build drying racks and sheds in the district of Merizo. In a few weeks he was followed by the most progressive Chamorro. For several months these two men were the only ones to use the new methods. At length one or two followed their lead, then others, and now practically every person who makes copra is employing these methods. The same thing happened in many other districts of the island.

EXTENSION WORK WITH CROPS.

Extension work with crops is directed toward the selection and planting of better seed, better methods of seed-bed preparation and cultivation, and the distribution of seed of new varieties.

During the month of March a campaign was begun to get more of the farmers to grow cowpeas. The proposition was made that any man would be supplied with enough seed to plant a small plat provided he would agree to give an equal amount of seed to some other farmer at the end of the season. A large quantity of seed was distributed under this plan, and much more could have been placed if the supply had not become exhausted. The following number of men in each of the districts were supplied with seed under these conditions: Forty men at Agat, 17 at Inarajan, 21 at Merizo, 20 at Talofofo, 20 at Umatac, and 27 at Yona, making a total of 145 men supplied with seed. A large quantity of improved mungo-bean seed was distributed in the same manner.

FARM IMPLEMENTS.

During the year efforts were made to encourage the general use of improved farming methods and implements among the farmers. This work was a continuation of what has been carried on by the station since its inception. In this case improved implements include small one-handled plows, and five-tooth or seven-tooth cultivators such as can be drawn by a carabao or bullock. These implements were imported by the island government and sold to the people at a low price. Most of these tools were sold during the last few months, when a special campaign for better seed-bed preparation and cultivation was conducted. It is encouraging to note that a large number of these implements went to districts where such tools had not been in use previously.

An example of the increased interest in farm implements was shown when the district of Merizo won first place in the community

contest at the last Guam Industrial Fair. The prize was to have been a large flagpole erected at a central place in the village. This district, however, had won a similar prize at the previous fair, so it became necessary to award something else. Various suggestions were made, such as building a large drinking fountain or constructing an arch over the street leading from the dock. The people of the district, however, asked that the money be invested in improved farm machinery to be owned by the community.

LIVE STOCK AND POULTRY.

The live-stock industry of Guam was greatly benefited during the year by the importation of live stock from the States and by the sale of the stock from the island government farm at Barrigada. The operation of this farm was discontinued, and the live stock was sold to private owners for breeding purposes. This stock consisted chiefly of high-grade Berkshire pigs. Fifty-seven of these animals were sold at the low price of 15 cents a pound, with the understanding that they were to be kept for breeding purposes and were not to be slaughtered. It is a part of the extension work of the station to keep in touch with the persons who have purchased these purebred and high-grade animals and to see that the proper methods are used in caring for them. In some instances, where the men who had bought purebred boars were not giving them the attention that they should have had, the station gave instructions and suggestions as to the proper methods of feeding and caring for the animals.

The station is also trying to persuade as many persons as possible to breed their sows to purebred boars. At the end of the fiscal year arrangements were being made to conduct a "Better Sires-Better Stock" campaign along the lines followed for similar campaigns in the United States.

TICK-ERADICATION DEMONSTRATION.

Two demonstrations in freeing cattle from ticks by means of spraying or washing with arsenicals dips have been started. One of these demonstrations is at Merizo and the other is at Inarajan. In both cases the stock solution was furnished by the station. Meetings were held in each of the two districts, and the method of mixing the solution and applying it to the animals was demonstrated. The material was then turned over to certain men who agreed to use it on their animals. These men are all well pleased with the results and state that the animals treated according to instructions are gaining weight much more rapidly than others. There is need of more work of this kind in Guam, where the tick is a great enemy to the cattle industry.

THE GUAM INDUSTRIAL FAIR.

A large part of the extension work with adults is carried on in connection with the Guam Industrial Fair. The average farmer ordinarily produces no more than is absolutely necessary to supply his own family, but he will work much harder and try to produce things of better quality if he has an opportunity to excel his neighbor in a contest. The fair is therefore an excellent means of arousing interest in the production of better crops and live stock.

The fourth Guam Industrial Fair was held from February 12 to 14, inclusive (Pl. VII, figs. 1 and 2). The date was changed from July to February because better weather prevails and more products are available for exhibition at that time. The latter date comes at the close of the main crop season. This fair surpassed the three previous ones in number of exhibits and in general interest.

The community contest again aroused much interest. Each district was allotted a space in the agricultural building in which to make a collective display of its farm products. The score card for these exhibits was revised so that it would be better suited to conditions. The first prize was won by the municipality of Merizo, with Inarajan a close second, and Dededo third. All members of the station staff took an important part in these fairs. The superintendent of extension acted as the head of the publicity, agricultural, and girls' and boys' departments.

DISTRICT FAIRS.

During the last few months of the fiscal year a great deal of time was devoted to the organization of a series of district fairs to be held during the next four months at Umatac, Merizo, Inarajan, Sumay, Agat, Yona, Dededo, and Asan. The fair of the last-mentioned district was to be devoted entirely to boys' and girls' clubs. The Guam Industrial Fair appropriated a small sum of money for each of these fairs. The remainder of the money for premiums and general expenses was raised by the people of the district. As this was an entirely new idea in Guam, it was necessary for the station to do a great deal of work to get the fairs organized and in working order. In most cases all the people in the district were asked to attend a meeting where the proposition of having a local fair could be explained to them. Later a fair committee was elected, consisting of a manager, a secretary, a treasurer, and one or more superintendents of each department. After learning what amount of money could be raised for the fair, the superintendent of extension met with the fair committee to assist them in making out their premium list. Each department received a list of suggestive products which might be offered. The local committee selected the things that they wanted

and added others which it was considered advisable to use. A value was then placed on the premiums, and rules were drawn up for the contestants. The premium list was prepared for the printer without cost other than for the materials furnished by the government print shop. Three premium lists have already been printed, and five others were being prepared at the end of the fiscal year. Publicity material and a mimeographed booklet of suggestions for organizing community fairs were prepared by P. Nelson of this station, who is head of the publicity department of the next Guam Industrial Fair.

Such exhibits are proving very popular and promise to be a great success. In the work of organizing these fairs the educational phase is kept in mind. The management is left to the people of the district, and although helpful advice and suggestions are given whenever necessary, no attempt is made to dictate to them. In this way the people learn some valuable lessons in cooperative effort and in self-government, as well as in producing crops and live stock of better quality.

SCHOOL GARDENS.

For a number of years school gardens have been maintained in connection with each of the schools of the island. This work is now conducted cooperatively by the Guam Station and the Department of Education of the island government. The supervision of the planting and the care of the gardens are a part of the extension work of the station.

Gardening is a required part of the course of study in the outlying districts. One-half day each week is devoted to working in the garden under the direction of a teacher. Under the present plan this work is done by the boys. The girls spend the same period in sewing, basketry, or work of similar nature. The purpose of the school-garden work, as far as the extension work of the station is concerned, is three-fold:

(1) To teach the boys and girls the best methods of planting, cultivating, and harvesting vegetables.

(2) To have the gardens serve as demonstrations to the people of the district.

(3) To furnish an organized means of distributing seeds and plants which have been found adapted to local conditions.

SEED AND PLANT PRODUCTION AND DISTRIBUTION.

Most of the seed for the gardens has been supplied by the experiment station. An attempt is now being made to have each school garden produce enough vegetable seed not only for its own use but also to supply the farmers of the district. Much of this seed can be produced in the school gardens. A number of the schools

distributed considerable seed during the year, especially of Kentucky Wonder and Lima beans.

At the garden of the Asan school the pupils planted cuttings made from various economic plants at the station. These plants are now being distributed among the people of the district. This work was supervised by one of the boys' club scholarship winners, who was receiving training at the station at that time. It is planned to extend the work of propagating and distributing plants to each of the school gardens in the outlying districts.

IMPROVED GARDEN TOOLS.

To give the children training in the use of modern garden tools, and to demonstrate their use to the people of the community, the island government has turned over four combination cultivators to the station. These tools have been placed in the gardens at Piti, Merizo (Pl. VIII, fig. 1), Inarajan, and Sumay, where they are now being used by the pupils.

MODEL SCHOOL GARDEN.

The school garden at Piti has been planned to serve as a demonstration to the other schools of the island. This garden is situated on the Piti-Sumay road, where it has attracted considerable attention. It is located on land belonging to the station, which furnishes practically all the tools used. The ground was plowed and fertilized with barnyard manure.

The garden is divided into plats 8 feet wide and 32 feet long. Competition was stimulated by giving each team of two boys—a large and a small one—a plat of their own. This spirit was strengthened by the offer of prizes by private individuals to the pupils growing the best gardens.

The vegetables grown in each plat include tomatoes, peppers, eggplant, Lima beans, Kentucky Wonder beans, carrots, lettuce, and radishes. Most of the vegetables produced were sold to the island market, and the money was divided among the boys.

All of the boys working in the school gardens of the island have been organized into companies of the United States School Garden Army and have been supplied with insignia and service flags. The fact that they belong to a national organization has served to intensify the interest of the pupils in their work.

BOYS' AND GIRLS' CLUB WORK.

This phase of extension work is proving to be the most popular and promises to have the most lasting effect of all the work begun. The children are more eager to learn than the older folks, and they

are more willing to put into practice the things they learn. As the younger generation of to-day will be the farmers of to-morrow, this work will no doubt be far reaching in its results.

The club work is carried on in cooperation with the schools of the island. By order of the Governor of Guam, club work is required in all the schools of the outlying districts. The membership of the clubs, however, is not limited to pupils, for any boy or girl under 19 years of age may become a member by enrolling and agreeing to follow instructions in the particular line of work he wishes to take up. The club activities supervised during the year included corn, bean, copra, taro, pig, and poultry. Good work was done in all these clubs. The largest enrollment, however, was in the poultry club. The club year is divided into two seasons, one beginning about November 1, and the other, March 15. For this reason the quantity of work that can be accomplished is twice as much as could be done in a more temperate climate. The following table gives the enrollment by districts and by activities for the season ending March 15, 1920:

Enrollment of boys' and girls' clubs, March 15, 1920.

District.	Project and number of members enrolled.						
	Corn.	Copra.	Bean.	Taro.	Pig.	Poultry.	Total.
Agana	.....	.....	5	.....	5	4	14
Agat	4	2	6	.....	14	33	59
Asan	12	4	12	8	13	24	73
Dededo	6	3	15	3	5	12	44
Inarajan	30	1	24	6	1	1	63
Merizo	13	6	13	5	9	13	59
Piti	1	.....	4	3	17	43	68
Sumay	18	1	21	8	1	11	60
Umatac	5	.....	7	7	6	22	45
Yigo	7	3	6	1	2	7	26
Yona	9	.....	1	.....	5	17	32
Total	105	20	114	41	78	187	543

CORN CLUB.

Members of the corn club are required to grow one-tenth of an acre of corn according to instructions. This area is seemingly very small, but it should be remembered that most of the work is done by hand, or with a carabao and a small one-handled plow, and that it takes at least one week to plow an acre with the implement used; consequently it requires more time to farm one-tenth of an acre in Guam than it does to farm one acre in the States.

Practically all of the native farmers plant corn too thickly, and then fail to thin it out. They evidently believe that the greater the number of stalks to the hill, the larger will be the yield. All club members were instructed to thin their corn to three stalks to the

hill after it was about one foot high. At first many of them could not understand why this method should be followed. One boy in the Dededo district was found to have as high as 15 stalks to the hill. As a club member on an adjoining ranch had thinned his corn according to instructions, the first boy was allowed to leave his corn as originally planted. Near the end of the season a field meeting of the members of the district was held, and the results of the two methods of growing corn were compared. The boy who thinned his corn had a high yield, while the other had practically no grain at all. This was very convincing proof of the value of growing only three stalks to the hill. During the first season, 38 per cent of the members thinned their crops. The second season the percentage was increased to 50, and many of the others had corn that did not require thinning. This increase shows that the boys are learning things which will be of value to them when they become farmers.

All members were instructed to save seed for the next season. Field selection, proper drying, and storage were stressed. Practically every member completing the work each season reported having selected and saved seed for planting.

BEAN CLUB.

Each member of the bean club is required to grow a plat of beans measuring at least 500 square feet. Any variety of native or imported beans may be grown. Cowpeas are also included. At the beginning of the first season most of the members were supplied with seed by the experiment station. The seed distributed included Lima and Kentucky Wonder beans and cowpeas. The boys and girls were instructed to save their own seed thereafter. More than 94 per cent of the members followed these directions and carried over enough seed to plant their plats the next season.

COPRA CLUB.

Members of the copra club are required to care for at least 10 coconut trees and make copra from the nuts. Copra is the chief money crop of the island, and is practically the only article of export. The copra club was organized for the purpose of teaching better methods of caring for the trees and making the copra, thus producing a product of higher quality. Practically all of the members reporting followed instructions and used drying racks and sheds instead of drying the meat of the nuts on mats and piling it in the house overnight or during a rain. Many of them grew cover crops. The majority did not follow the native custom of picking immature nuts from the trees, but waited until the coconuts were fully matured and fell to the ground. They then stored the nuts in a dry place until

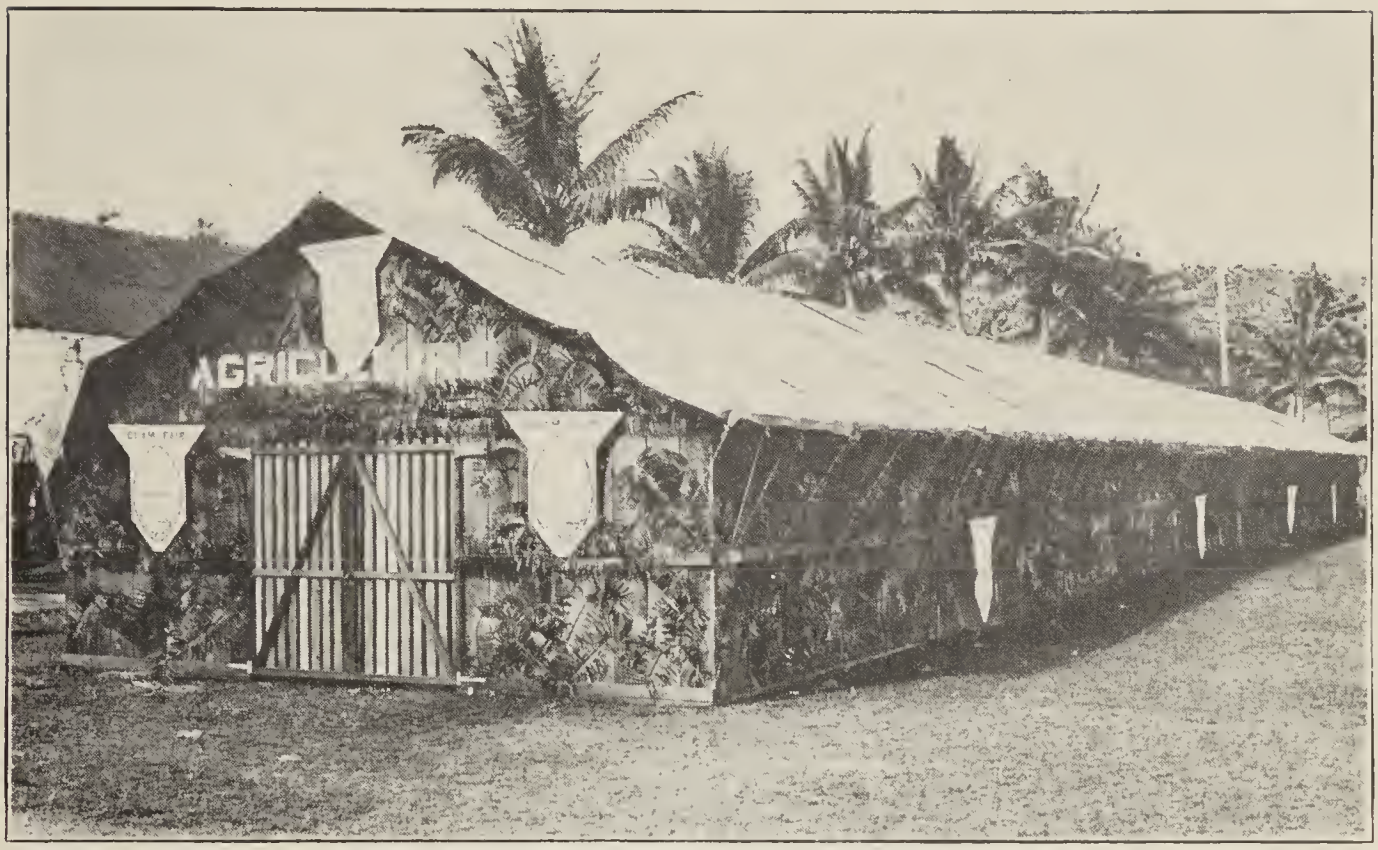

FIG. 1—GUAM FAIR AGRICULTURAL BUILDING.

FIG. 2.—GUAM FAIR BOYS' AND GIRLS' CLUB BUILDING.

FIG. 1.—MERIZO SCHOOL GARDEN.

FIG. 2.—MEMBERS OF ASAN PIG CLUB WEIGHING THEIR PIGS.

weather favorable for copra drying arrived. As a result of following instructions the club members produced a superior quality of copra, which was purchased in most cases at a price higher than that paid by the market.

TARO CLUB.

The taro club was started for the purpose of encouraging the growth of this important crop. Taro is especially important as an emergency food crop. In case of a typhoon, such as occurred on the island two years ago, it can be used as a dried-food product. A member of the taro club is required to grow a plat of taro of an area of at least 500 square feet.

The enrollment in the taro club was not as large as in most of the other activities, because a considerable part of the farm land is not adapted to the growing of this crop. It is planned to change the taro club to a root-crop club and include such crops as sweet potatoes, cassava, yams, and edible canna. Such a change will make it possible to have members in every part of the island.

PIG CLUB.

Boys and girls who join the pig club are required to raise at least one pig according to instructions (Pl. VIII, fig. 2). Good results are already beginning to appear in the pig club. The native practice is to keep the pig tied to a tree, or stake, by a short rope secured to the foreleg. Most of the club members have built pens, and a few allow their pigs free range.

An attempt is being made to have all pig-club members own Berkshire pigs. The Berkshire is the only improved breed that is being introduced into the island. A start in this direction was made during the year, when a number of the members purchased high-grade gilts from the island government at the time of the sale of the live stock at the Barrigada farm. One boy bought one of the purebred boars imported from the States. Other members have pigs from grade boars that were placed in various parts of the island by the station. The problem in the pig-club work is how to supply improved animals to all those who want them.

All members owning female pigs are required to breed them to purebred boars if there are any in the community. Animals of this kind are now available in many of the districts. Grade Berkshire boars are located in many of the communities. One of the best pig clubs on the island is at Asan. Most of the members own high-grade gilts. The supervisor has purchased a purebred boar, and all members are required to breed their pigs to it.

POULTRY CLUB.

This club activity has been found to be the most popular of all. Although each member is required to set at least 10 eggs and raise the chickens from them, most of the boys and girls raise more than the required number. All poultry club members are encouraged to raise chickens of an improved variety. Many of the members purchased purebred Rhode Island Reds from the shipment imported from the States in February. Others have been supplied with eggs from the station.

LOCAL CLUB ORGANIZATION.

All the club members of each district are grouped into one organization, regardless of the club activity pursued by them. For example, in the district of Sumay all the pig, poultry, corn, taro, bean, and copra members belong to the organization known as the Sumay Boys' and Girls' Club. Acting upon the advice of the superintendent of schools, the superintendent of extension appoints a club supervisor, who, in most cases, supervises the local school. He is held responsible for the work in his district and holds metings of the local club at least once every two weeks; more frequently if necessary. At these meetings he receives reports from the members on the progress of their work. The supervisor keeps a record of the work done by the members, each of whom is supplied with special blanks for the purpose. Each supervisor also makes an inspection of the work of his members at intervals of about two weeks. A meeting of all the supervisors and their assistants is held on the first and third Saturdays of each month in Agana. Teachers from the south end of the island attend only one meeting a month, on account of the lack of transportation facilities. At each meeting the supervisors make reports on the progress of the club work in their districts. At the same time the printed instructions to members are explained and discussed, and suggestions for the improvement of the work are given.

INSTRUCTIONS.

Instructions are given by printed circulars and letters and by personal visits. Printed instructions in the form of leaflets are issued each month for each club activity. These circulars are supplemented by special notices and letters which are sent out from time to time. Since the children use the Chamorro language at practically all times except when in school, the instructions are written in simple words and convey only a little information at a time. Seventy instruction leaflets were prepared and published during the year.

Personal visits are made to each district at intervals during the season for the purpose of inspecting the work of the club members and of giving personal instruction. Usually the supervisor and all the members of the local club visit each boy's and girl's demonstrations. At each place a discussion on the merits of the work is held, and suggestions are given for improving it. In this way each member sees just what the others are doing and makes an effort to have his work in better condition than the others.

REPORTS AND STORIES.

Each club member is required to keep an account of his work and to make out a report and write a story of his activities at the end of each season. Special report blanks suited to Guam conditions have been prepared and distributed to club members for this purpose. On account of the close personal supervision over the work of the members by the supervisors and extension workers, the percentage of complete reports turned in at the end of each season has been unusually high. For the season ending March 15, 1920, 80.1 per cent of the boys and girls submitted reports.

PRIZES.

While the educational side of the club work is featured, it is found that prizes of various kinds are of great value in stimulating interest in club activities. At the last Guam Industrial Fair one of the features was a department devoted to boys' and girls' clubs. The exhibits were a great surprise to most of the people, both in quantity and in quality. A total of 377 exhibits was made by club members. This number included 250 entries of crop-club products, 40 pigs, and 87 trios of chickens. Each of the eight district fairs, which are to be held during the early part of the next fiscal year, will have a club department in which substantial prizes will be offered.

SCHOLARSHIPS.

A scholarship of three months' training at the station was awarded to the boy in each of the 10 local clubs who made the highest total score in his work for the season. In awarding these prizes, each member was graded according to the following cards:

Score card for crop-club members and pig and poultry club members.

Crop club.	Points.	Pig and poultry club.	Points.
Yield	30	Success in raising pigs and poultry	30
Exhibit at Guam Fair	20	Exhibit at Guam Fair	20
Report and story of season's work	20	Report and story of season's work	20
Education and general qualifications	30	Education and general qualifications	30
Total score	100	Total score	100

During the year five boys who had won scholarships in the boys' club work were trained for three months in practical agriculture at the station. These boys were taken on as apprentices and received the regular apprentice's pay, which helped to defray their living expenses. One group worked in agronomy and horticulture, receiving instruction in the fundamental principles of seed-bed preparation, planting, transplanting, seed testing, harvesting, propagating plants by budding, inarching, and layering, methods largely unknown to most of the natives of the island. The other group was assigned to the live stock and poultry. At the end of six weeks the groups changed work. This gave every boy a chance to work in all departments of the station during the three months of training. Short talks and demonstrations were given by the members of the station staff at stated times. A certain amount of reading was also assigned to each boy. Most of the training, however, was given by having the boys actually do the work in the fields and barns under the supervision of a trained man. Thus the training of the boys in no way interfered with the regular station activities.

Through the cooperation of Mr. S. Freegord, of the Department of Industries of the island government, the scholarship winners were taken on trips to the island government farms at Barrigada and Libugan and to the governor's garden in Agana. A trip was also made to Merizo to study copra making. Throughout the course the boys were required to take notes and write reports on the work accomplished and the things learned.

It is to be regretted that owing to lack of funds near the close of the fiscal year the boys could not be paid after the first week in June and their period of training was cut down by three weeks. It is expected that the results of training these club members at the station and having them return to their districts as farmers and teachers will have a beneficial influence on the agriculture of the island. It is hoped that this plan can be repeated at least once each year.

CORRELATION OF CLUB WORK WITH SCHOOL WORK.

As most of the club members are school children the club work is being correlated as closely as possible with the school work. It is very easy to devise such methods, because the club work is conducted in close cooperation with the schools. The club instructions can be used as a part of the reading lessons and in the study of English. The figuring out of the areas of club plats, the yields of crops, the weights of pigs, and the like, can be made into practical problems in arithmetic. Practice in composition and grammar can be secured by

the writing of club stories. Practically all of the teachers have learned that the children take a great deal of interest in their school subjects when they are taught in the concrete rather than in the abstract, and that they make more progress when they are interested in and understand their subjects.

CLUB SUPERVISORS RECEIVE TRAINING IN THE UNITED STATES.

During the year four boys were sent to the United States for training as teachers. The funds for this purpose were supplied by the island government. Two of these young men were teachers—one a club supervisor, and the other his assistant. Of the other two, one was an office worker and the other a student. They are now attending the Oklahoma Agricultural and Mechanical College and are under contract to return to Guam as teachers. It is expected that these boys will be of great assistance to the club work when they return, because they will have received training that will fit them for positions as club supervisors in connection with their teaching work.

ACKNOWLEDGMENTS.

A report of the junior extension work in Guam would not be complete without an acknowledgment and an expression of appreciation of the cooperation of the schools of the island, and especially of the cooperation of Capt. A. W. Stone, United States Navy, head of the Department of Education, and Mr. J. Schnabel, superintendent of schools.

METEOROLOGICAL OBSERVATIONS, 1920.

By P. Nelson, *Assistant.*

The weather conditions during the year may be considered as having been normal. No disastrous typhoons visited the island. The rainfall of the year, with the exception of August and September, when it was excessive, was sufficient to make ideal growing conditions. There were several stormy periods during September and October, but as they occurred at a time of excessive rains, when it was impossible to do any planting, no material damage was done to crops.

Atmospheric pressure.—During the first two weeks of August the barometer was rather unsteady. A heavy surf from the southwest indicated that a typhoon had been ranging somewhere in the vicinity of the island. Strong winds and a falling barometer occurred on September 29 and 30, and at intervals the wind reached a high

velocity. The lowest reading of the barometer during this storm was 29.521 inches, recorded at 11.45 a. m. September 29. On October 15 the barometer commenced falling, and unsettled squally weather prevailed until October 17. During these three days the barometer remained low and fell to 29.366 inches at 3.25 p. m. on October 17. Except for these periods of stormy weather, the barometer was fairly steady during the year. The mean of the daily readings taken at 4 p. m. was 29.769 inches. The maximum, 29.935 inches, was recorded on February 29, and the minimum, 29.376 inches, was noted on October 16.

Temperature.—The mean temperature of the year was 81.76° F. which was a trifle lower than that recorded for last year. May was the warmest month of the year, having a mean temperature of 83.29° F. December was the coolest month of the year, having a mean temperature of 80.24° F. The absolute maximum of the year, 99.5° F., was recorded February 3, 1920; the absolute minimum, 73° F., occurred on May 5 and 6, 1920. A temperature of 90° F. or over was observed on 97 days of the year. The greatest daily range, 24.5°, occurred on February 3, 1920; and the lowest, 4°, on December 20, 1919. The mean dry-bulb temperature for the year was 81.31° F.; the wet-bulb thermometer was 77.09° F. From the dry and wet bulb readings the following data were calculated: Mean dew point, 75.4°; mean relative humidity, 85.26 per cent; and mean vapor pressure, 0.886 inches.

Rainfall.—Although the year had slightly less rainfall than the two previous years, rain fell on a considerably greater number of days. The total precipitation recorded for the year amounted to 90.89 inches. The period from July to December, with 157 days of rainfall totaling 65.21 inches, proved to be wettest, and January to June was the driest, having 25.68 inches in 118 days. The total number of days with rainfall was 275 days. Not a month had less than 15 days with rainfall. August was the wettest month, with 26 per cent of the total, while February was the driest, with 2 per cent. Twenty-five days had 1 inch or more rainfall. The maximum precipitation for 24 hours occurred on August 6, when 3.85 inches was recorded.

Velocity and direction of wind.—The average hourly velocity of the wind was 6.07 miles. The prevailing direction was northeast, with 38.5 per cent. East was next, with 21.7 per cent; southeast, with 14.2; north and south, each with 7.2 per cent; followed by west, southwest, and west, with less than 5 per cent of the total.

The following table gives a summary of the meteorological data collected within the year:

Condensed meteorological data for the fiscal year 1920.

Month.	Temperature.					Relative humidity (monthly mean).	Total precipitation.	Wind.	
	Maximum.	Minimum.	Mean maximum.	Mean minimum.	Monthly mean.			Prevailing direction.	Average hourly velocity.
1919.	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	*Per cent.*	*Inches.*		*Miles.*
July	90.5	74.0	88.01	76.66	82.34	86.60	7.58	NE.	4.53
August	90.5	74.5	86.14	77.11	81.62	93.09	23.65	S.	5.68
September	93.0	73.5	87.33	76.81	82.07	89.53	14.13	N.	4.05
October	92.5	75.5	87.03	77.65	82.34	90.33	6.1	E.-NE.	6.21
November	90.0	73.0	84.85	77.11	80.98	87.76	8.52	NE.	6.72
December	85.0	74.5	83.65	76.83	80.24	90.26	5.23	NE.	7.61
1920.									
January	92.0	71.0	88.68	75.10	81.89	82.20	2.01	NE.	7.67
February	99.5	74.0	89.07	75.38	82.23	79.34	1.92	NE.	10.11
March	93.5	73.0	89.91	75.77	82.84	77.70	6.00	NE.	7.47
April	92.5	74.0	89.55	76.32	82.93	77.44	4.34	NE.	6.36
May	93.0	73.0	89.96	76.62	83.29	82.90	6.09	N.	3.53
June	91.5	75.0	89.08	77.28	83.18	82.36	5.32	SE.	2.90